ēKo PRO Series

USERS MANUAL

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NEXT GENERATION WIRELESS FOR PRECISION AGRICULTURE • by CROSSBOW TECHNOLOGY, INC.

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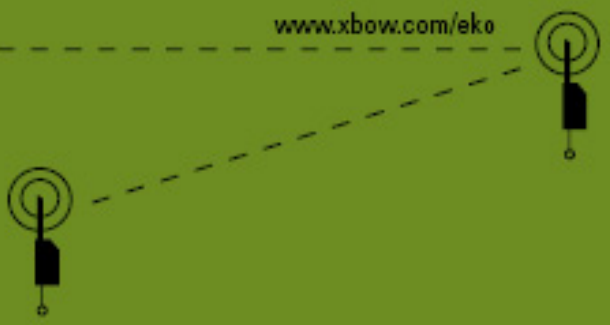


Table of Contents

About This Document

The following annotations have been used to provide additional information.

◂ NOTE

Note provides additional information about the topic.

☑ EXAMPLE

Examples are given throughout the manual to help the reader understand the terminology.

IMPORTANT

This symbol defines items that have significant meaning to the user

⚠ WARNING

The user should pay particular attention to this symbol. It means there is a chance that physical harm could happen to either the person or the equipment.

The following paragraph heading formatting is used in this manual:

1 Heading 1

1.1 Heading 2

1.1.1 Heading 3

This document also uses different body text fonts (listed in Table 0-1) to help you distinguish between names of files, commands to be typed, and output coming from the computer.

Table 0-1. Font types used in this document.

Font Type	Usage
`Courier New Normal`	Sample code and screen output
`Courier New Bold`	Commands to be typed by the user
Times New Roman Italic	Files names, directory names
Franklin Medium Condensed	Text labels in GUIs

1 Introduction

This *User's Manual* describes the features and operation of the ēKo Pro series wireless sensor network system.

1.1 ēKo Pro Series Overview

ēKo is a wireless, agricultural and environmental sensing system for crop monitoring, microclimate studies and environmental research. ēKo introduces both a new generation of sensor integration and wireless technology. The key features of the ēKo system include:

- **Monitoring and Recording Sensor Measurements -** ēKo records all sensor measurements, from many different sensor types, locally in the ēKo gateway's database to log a complete history of sensor data across different microclimates, topologies and soil types. The gateway's web service, ēKoView, supports remote internet access via standard web browsers to view data bar charts, trend charts, and map views, allowing users to pinpoint and drill down into data. Users can manage all information from a single web browser remotely monitoring one or many ēKo networks.
- **Immediate Notification and Alerting -** Individual sensor measurements can be setup to trigger by threshold or level, and alert unacceptable and out of range conditions via email or mobile text message.
- **Plug-and-Play for Sensors and Nodes -** Each ēKo wireless node supports up to four sensors. Sensors are simply plugged into the unit; there is no additional work required such as connecting wires to terminal blocks or changing jumper configurations. This operation can be done within a few seconds. Once the ēKo node is reset it scans the sensor ports to auto-identify the sensors. Anytime an ēKo node is reset it will immediately interrogate neighboring units to locate good radio connections. After one minute the user is notified if the node is placed correctly.
- **Network Scalability -** Expanding the network is as simple as turning on another ēKo node, as each ēKo node has the ability to forward messages from other units that are within communications range, with typical ranges from 600 to 1500 feet depending on placement, obstacles, and radio interference. A single ēKo system can support up to 35 ēKo nodes and 140 sensing points.
- **Extended Power through Solar Energy -** ēKo nodes are solar-powered with rechargeable batteries to ensure that the sensors stay up and running for years on out. Nodes can run up to 3 months without sunlight.
- **Flexible Sensor Interface -** ēKo nodes are designed to accommodate almost any type of low power sensor and allow for future support of many sensors. Two different types of sensor interfaces are supported: Simple for standard 2 and 3 wire sensors and Smart which uses Crossbow's ESB (Environmental Sensor Bus) for intelligent sensors. As new sensors are introduced users will be able to simply connect them to the nodes using the ēKo's auto-identification scheme.

1.2 ēKo Pro System Components

1.2.1 eN2100 wireless sensor nodes consisting of

Figure 1-1. Photo of the eN2100 ēKo node

1. Four sensor ports that support any combination of
   - eS1101 soil moisture and temperature sensor
   - eS1110 soil water content sensor
   - eS1201 ambient temperature and humidity sensor
   - eS1301 leaf wetness sensor
   - eS1401 solar radiation sensor
2. 2.4 GHz IRIS family radio/processor module
   - Uses Crossbow's low power, multi-hop, mesh networking software.
   - Radio range of 500 to 1500 feet depending on deployment.
   - Radio power output of 2 mW.
   - Dipole antenna.
3. Small solar cell charging circuit and three NiMH batteries
4. Internal monitoring of solar voltage, battery voltage and internal temperature

1.2.2 eB2110 base radio and eG2100 gateway

Figure 1-2. Photo of the eB2110 ēKo base radio and eG2100 ēKo gateway

1. eB2110 ēKo base radio
   - A 2.4 GHz IRIS family radio/processor module to manage the network of ēKo nodes. The base radio relays all network radio messages from the network to the ēKo gateway.
2. eB2100 ēKo gateway
   - Controls the base radio station.
   - Runs Crossbow's XServe network management code.
   - Supplies web services for remote viewing of data and network health.
   - Connects to the ēKo base radio via a USB cable and also connects to the Ethernet via an RJ45 connector.

1.2.3 ēKoView web-based software interface

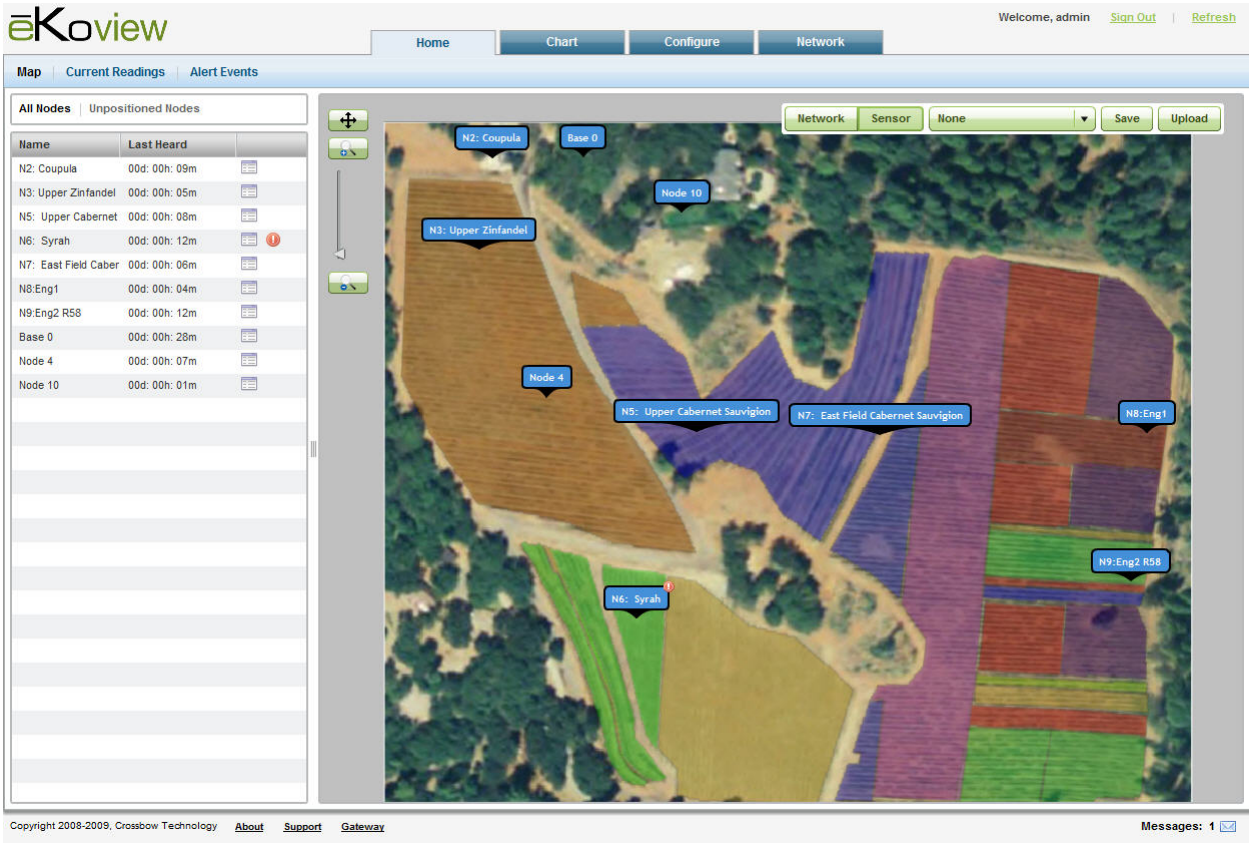


Figure 1-3. Screenshot of the ēKoView interface

ēKoView offers a familiar and intuitive web browser based (i.e. Internet Explorer, Firefox etc) interface for sensor network data visualization. Key features include:

- Map view to visualize network topology and sensor data relative to a background map
- Charts wizard to create trend charts of multiple sensors across customized time spans
- Network diagnostic tools to performance of network and health of individual nodes
- Tabular, searchable view of the data using Data view
- Alert manager to set alert levels and notify via email

1.3 ēKo Pro System Overview

The Figure 1-4 shows a basic ēKo system. Multiple ēKo nodes transmit sensor data back to the ēKo base radio which then forwards the data to the ēKo gateway.

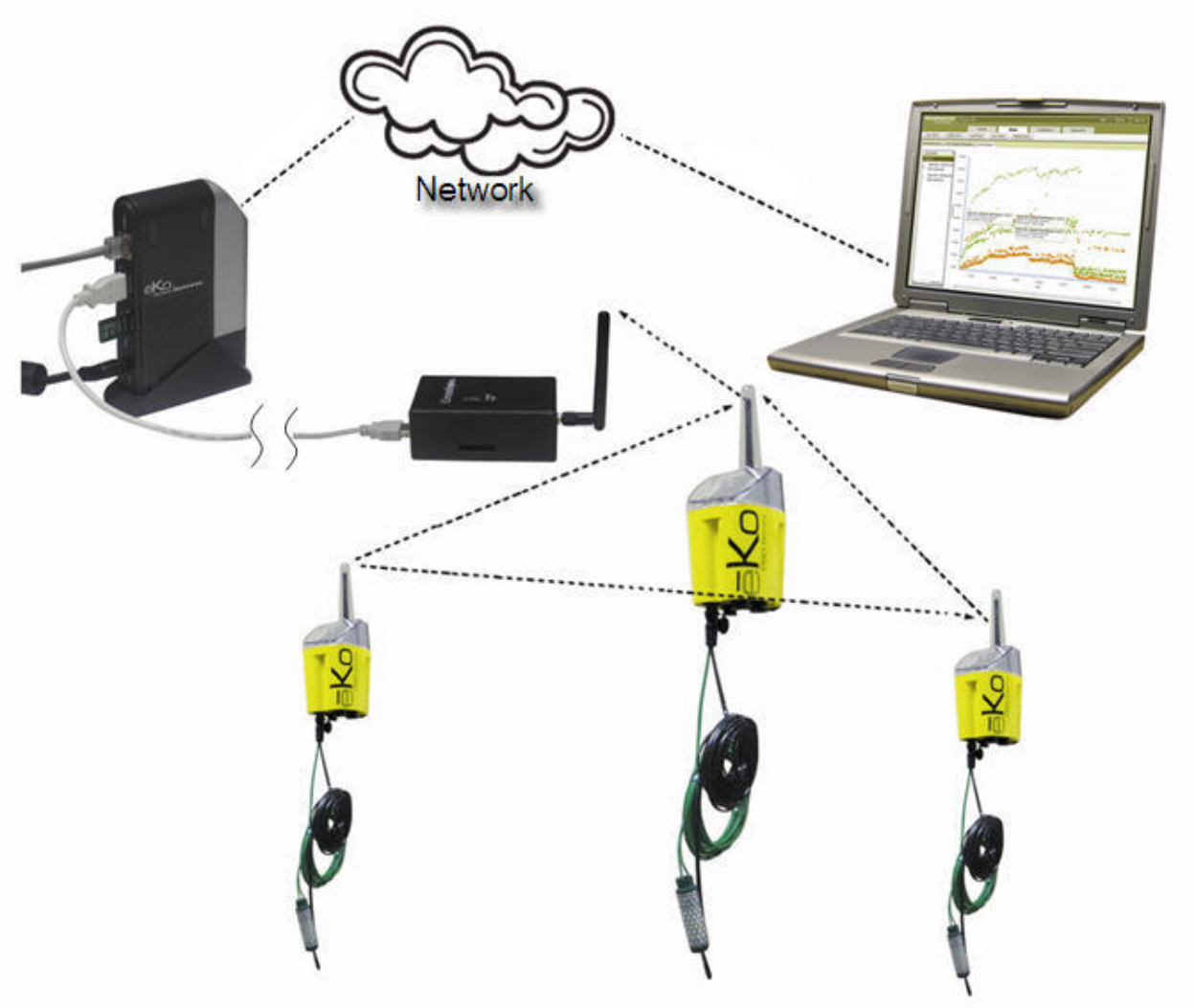


Figure 1-4. ēKo Pro series system overview

ēKo's radio mesh network is based on Crossbow's proprietary XMesh technology. The nodes extend their radio range by hopping messages. All ēKo nodes can originate sensor data and also forward data from other ēKo nodes. ēKo nodes without sensors can be placed anywhere to act as repeaters if required. Each node monitors the radio traffic in its neighborhood and keeps track of possible alternate radio paths. If one path is blocked or degrades it will switch to an alternate path.

The ēKo gateway stores and forwards (optional) data from the sensor network. The ēKoView web service allows users to remotely view sensor data via the internet and monitor the network. The gateway will connect to any standard Ethernet hub or router.

2 ēKo Pro Hardware Overview

2.1 ēKo Gateway

The ēKo gateway is an embedded Sensor Network gateway device. It is based on the Intel IXP420 XScale processor running at 266MHz. It features one wired Ethernet and two USB 2.0 ports. The device is further equipped with 8MB of program FLASH, 32MB of RAM and a 2GB USB 2.0 system disk.

The ēKo gateway runs the Debian Linux operating system. It comes preloaded with Crossbow's Sensor Network management and data visualization software packages, ēKoView and XServe. Those programs are automatically started when a Sensor Network base radio is plugged into the secondary USB port.

Figure 2-1. Photo of the ēKo gateway

The eG2100 ēKo Gateway package includes:

- 1 x ēKo Gateway
- 1 x USB Flash disk
- 1 x power supply
- 1 x vertical stand
- 1 x Ethernet cable
- 1 x CD with the software and documentation

2.2 ēKo Base Radio

The eB2110 ēKo base radio provides, in a fully integrated package the connection between ēKo sensor nodes and ēKo gateway. The base radio integrates an IRIS family processor/radio board, antenna and USB interface board which is preprogrammed with Crossbow's XMesh low power networking protocol for communication with ēKo nodes.

The eB2110 ēKo base radio provide a direct sequence spread spectrum radio (DSSS) supporting a wireless sensor network operating in the 2.4 GHz global ISM band. The USB interface is used for data transfer between the base radio and the ēKo View application running inside the ēKo gateway.

Figure 2-2. Photo of the ēKo base radio

The eB2110 ēKo base radio package includes:

- 1 x ēKo base radio
- 1 x USB cable

2.3 ēKo Node

The eN2100 ēKo node is a fully integrated, rugged outdoor sensor package that uses energy-efficient radio and sensors for extended battery life and performance.

The ēKo node integrates an IRIS family processor/radio board and antenna that are powered by rechargeable batteries and solar cell. The ēKo node provides a direct sequence spread spectrum radio (DSSS) supporting the 2.4 GHz global ISM band. ēKo node is capable of outdoor radio range of 500 to 1500 feet depending on deployment. The nodes come preprogrammed and configured with Crossbow's XMesh low power networking protocol. This provides plug-and-play network scalability for wireless sensor network.

The eN2100 ēKo node consists of the following:

- Four sensor ports (connectors) supporting any combination of eS1101 or eS1201 sensors
- IRIS family 2.4GHz radios pre-programmed with Crossbow's XMesh low power networking protocol.
- Dipole 2.4 GHz antenna
- Battery holder for 3 NiMH rechargeable AA batteries. These batteries are delivered fully charged and should be able to power the unit 3-4 months without sunlight.
- Solar cell and recharging circuitry.
- On board internal sensing of temperature, solar cell voltage and battery voltage.
- On and OFF buttons
- Multicolor status LED
- Waterproof enclosure with mounting bracket

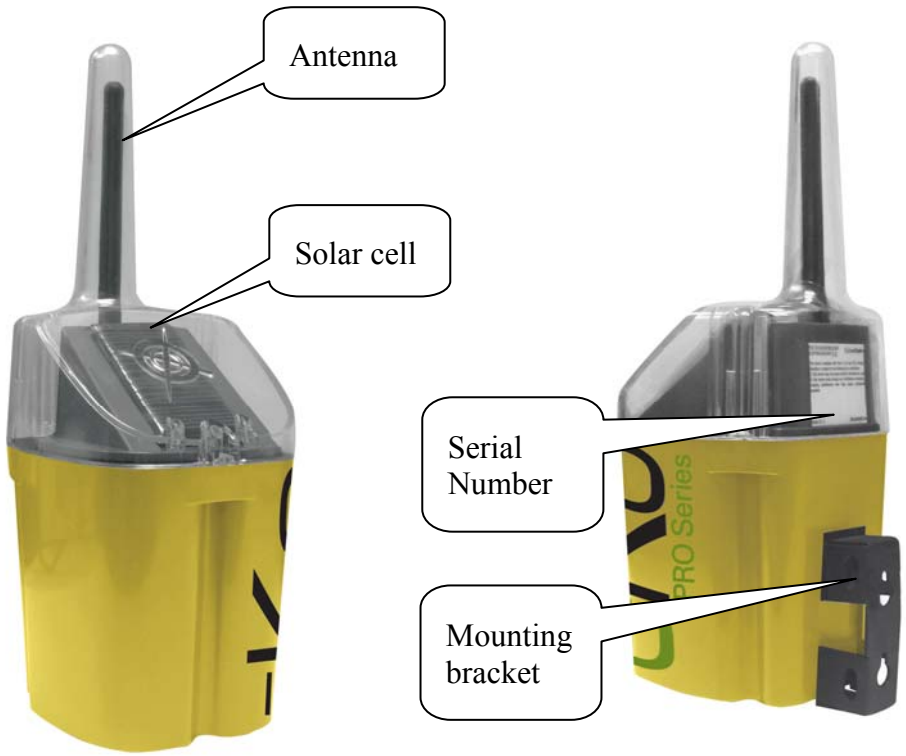


Figure 2-3. Front and rear views of the ēKo node

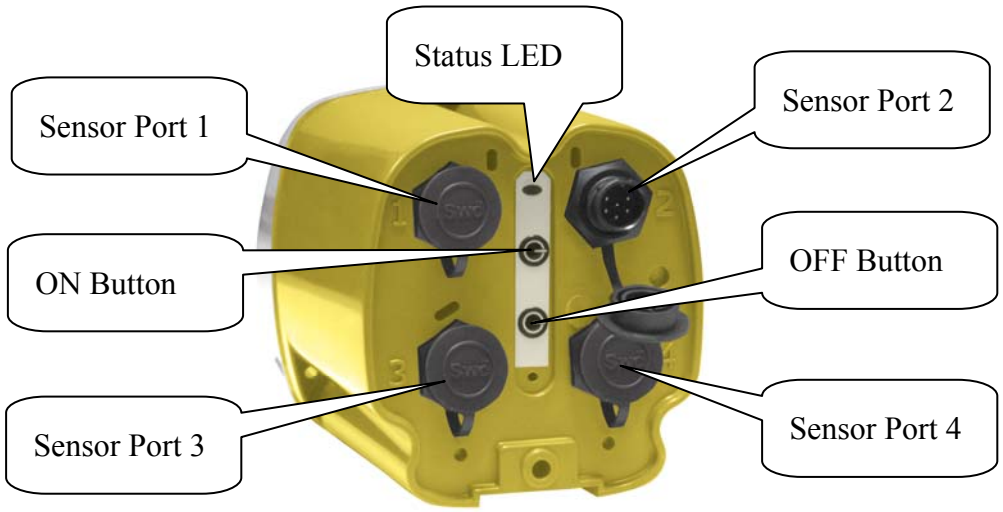


Figure 2-4. Bottom view of the ēKo node

2.4 ēKo Sensors

2.4.1 eS1101 soil moisture and soil temperature sensor

The eS1101 consists of a Watermark soil moisture sensor and soil temperature sensor which temperature compensates the Watermark sensor. Up to four eS1101s can be connected to one ēKo node to measure soil moisture at different soil depths.

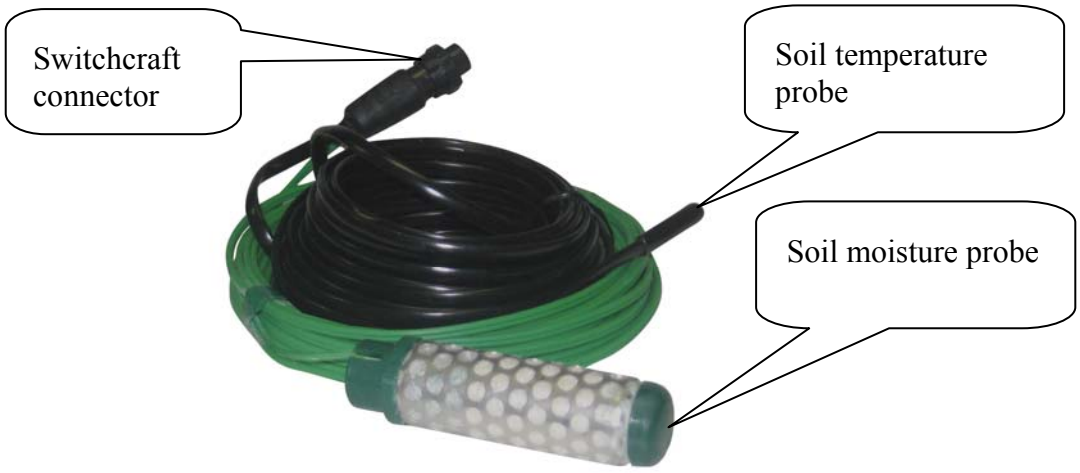


Figure 2-5. eS1101 Soil Moisture and Soil Temperature Sensor

The Watermark provides accurate readings from 0 to 200 centi bars. This covers the entire soil moisture range required in irrigated agriculture, even in the heavier clay soils. The Watermark measures soil water tension or suction which is a direct indicator of how hard the plant root system has to work to extract water from the soil. The drier the soil, the higher the reading. By monitoring the sensors between irrigations, it is possible to measure the rate at which the soil is drying out.

2.4.2 eS1201 ambient temperature and humidity sensor

The eS1201 Temperature/Humidity sensor measures relative humidity and air temperature. These readings are also used to calculate dew point. The sensor enclosure protects the sensor from mechanical damage, and a membrane filter protects the sensor elements from dust, dirt, and water spray. The housing includes a cable strain relief.

Figure 2-6. eS2101 ambient temperature and humidity sensor

To ensure accurate readings when measuring outdoor air temperature and humidity, the eS1201 should be shielded from direct sunlight and other sources of reflected or radiated heat. The eS1201 uses is a single chip, integrated circuit to measure relative humidity and temperature, generating a calibrated digital output.

For detailed specifications and operation of the sensors, refer to Chapter 8.

Crossbow continues to add new eKo compatible sensors to its offering. For the most up to date list, check our website http://www.xbow.com/eko

3 ēKo Gateway Set-up and Configuration

This section will step you through the process of setting up and configuring the ēKo gateway. The three main steps are to

1. Set-up ēKo gateway
2. Set up ēKo base radio
3. Start up the system and log into ēKoView

3.1 Setting-up the ēKo Gateway

To get started and set-up the ēKo gateway

1. Remove the ēKo gateway from its packaging. An included base can be used for upright operation.
2. The bag holding the ēKo gateway also contains an USB FLASH disk included in the package. Insert this device into the bottom USB port of the ēKo gateway labeled "Disk 1".

IMPORTANT: Make sure that the side with the electrical contacts on the USB disk mates with the contacts inside the USB connector. If the USB disk is plugged in the wrong way the ēKo gateway will not boot. See Figure 3-1 below.

3. Also included are a CAT5 Ethernet cable and a snap-on inductor. For optimal noise reduction, place the inductor close to the connector that will plug into the ēKo gateway and snap it in place.
4. Connect the Ethernet cable to the ēKo gateway's Ethernet port. The other end would typically plug into a Router or Ethernet hub/switch.

Figure 3-1. ēKo gateway connections

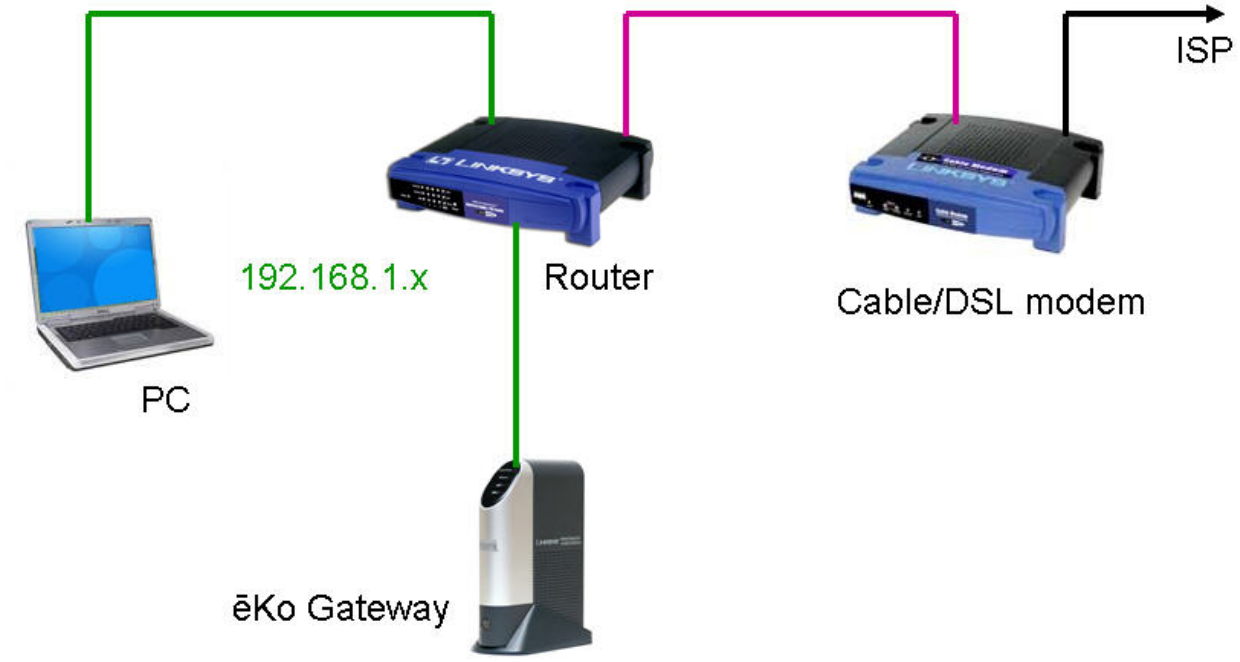


Figure 3-2. Typical network configuration

3.2 Setting up the ēKo base radio

1. Remove the ēKo base radio from its box
2. Connect one end of the USB cable to the USB connector of the ēKo base radio and plug the other end of the cable into the remaining USB slot on the ēKo gateway labeled "Disk 2".

Figure 3-3. ēKo base radio connections

The ēKo base radio receives radio messages from the deployed ēKo nodes. It is can easily be mounted indoors on a window or window ledge. Several other deployment options are also available (see section 5.1).

3.3 Starting the system

1. Insert the included power adapter into a standard electrical outlet and plug the power connector into the ēKo gateway. Upon application of external power, the ēKo gateway

will automatically power-up. Check the 'power-on' button on the lower front. It should now be illuminated. It takes about 2 minutes for the gateway to become fully operational.

Figure 3-4. ēKo gateway LED indicators

2. After the ēKo gateway has powered up, you should see the front indicators showing the following status.

Table 3-1. ēKo Gateway LED status description

Indicator	Color	Status
Power Button	Green	System on
Ready/Status	Green/flashing Yellow	System running
	Yellow then flashing Green	System boot
Ethernet	Flashing Green	Network activity
Disk2	Solid Green	XServe Running
Disk1	Green	USB disk running

3. At the end of the boot-up period, ēKo gateway will emit an audible beeping sequence, which can be decoded to find the IP address (Refer to section 7.1).
4. Wait for the "Disk 1" LED to turn green; this will take 1 to 2 minutes.

IMPORTANT: To turn off the power, press the power button. This allows ēKo gateway to correctly shutdown the operating system and takes about 40 seconds. Do not shut down the gateway by just unplugging it, this can cause corruption of its files.

3.4 Starting up ēKoView

The primary interface to the ēKo gateway can be accessed using a Web browser on a locally connected PC.

3.4.1 System Requirements

- PC connected to the Internet.
- Web browser, e.g. Microsoft's Internet Explorer or Mozilla's Firefox
- Adobe's Flash Player 9.x. To install Flash Player 9.x visit Adobe's web site:

  http://www.macromedia.com/software/flash/about/

NOTE: If you are unsure whether Flash 9.x is already installed on your PC, continue with the login steps. If Flash 9.x is not installed, your web browser will prompt you to install Flash 9.x and will guide you through the steps to do so.

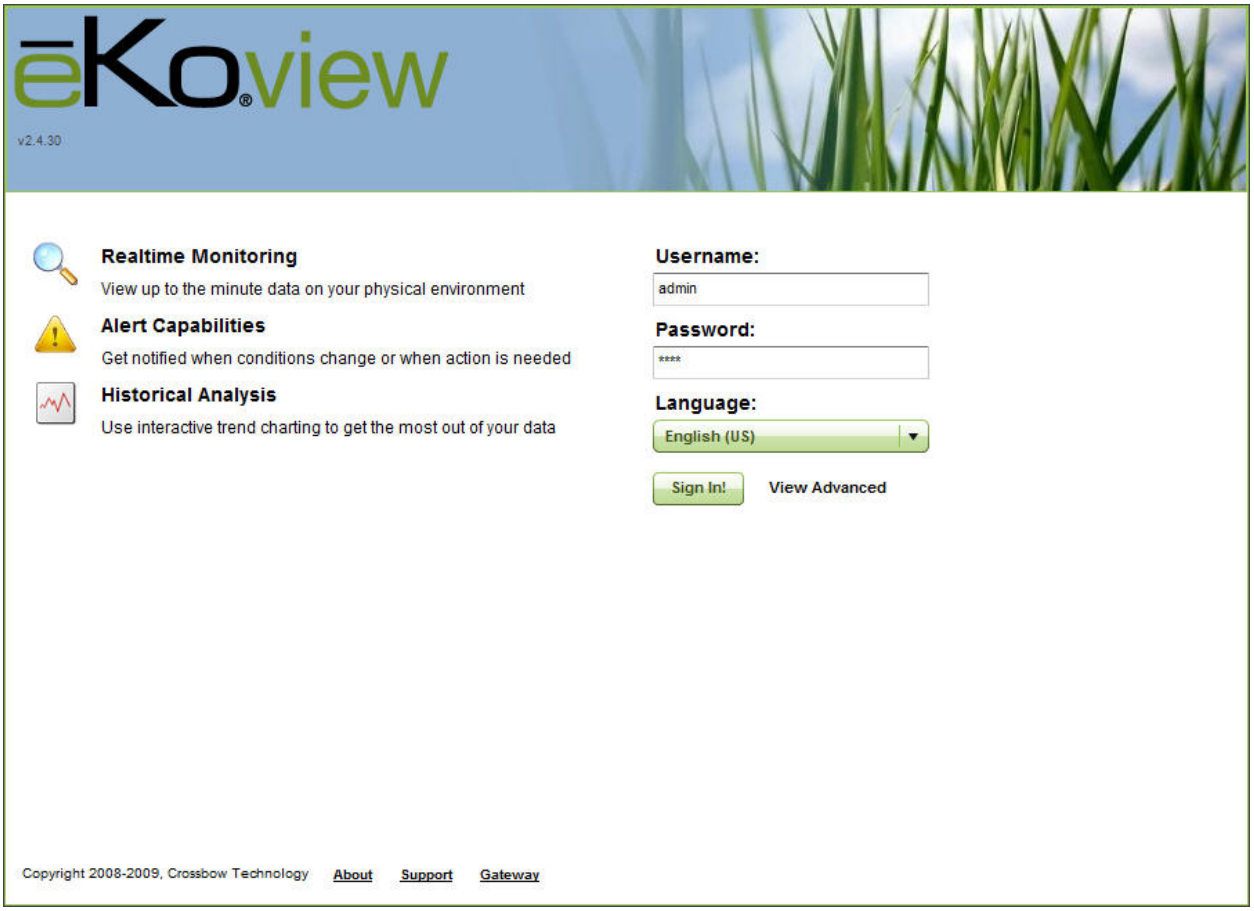
3.4.2 Opening ēKoView URL

ēKoView is a web-based application and can be accessed through a PC's web browser. To access the application, users will need the ēKoView URL address.

1. Open a web browser (eg. Internet Explorer or Firefox)
2. The following URLs will bring up the ēKoView welcome page:

   http://*eko-xxxxx*

   where xxxxx is the serial number written on a sticker attached to the bottom side of the gateway)



IMPORTANT: If the name on the sticker does not bring up the ēKoView welcome page, users will need to use the IP address of the ēKo gateway device instead of the hostname. The IP address of the ēKo gateway can be found either using the GatewayFinder tool (see section 7.1)

3. ēKoView requires a username and password to login. Type the default values below and click on **Sign In!**.

   Username: admin

Password: crossbow

NOTE: If you do not have Adobe's Flash 9.x installed in your browser, you will be prompted by your browser to install it. Follow the instructions given by your browser and then retry the above steps.

For users on a corporate or university network, the hostname should be enough to allow users to find the application through the browser. Most home routers do not support the means to use the hostname. In those cases users will need to use the IP address of the ēKo gateway device. The IP address of the ēKo gateway can be found either using the GatewayFinder tool or using the beep sequence (see section 7.1).

3.4.3 Changing the time zone of the ēKo gateway

The ēKo Gateway ships pre-configured from the factory with US Pacific time zone. Since the data is time-stamped relative to the time zone, users living is different time zone should change this. The ēKo Gateway Administration page allows user to change this default time zone. Refer to section 7.3.4 for details on how to do this.

4 ēKo Node Commissioning

Before deploying the ēKo system, you first need to register them with the ēKo gateway and this process is called node commissioning.

4.1 Pre-commissioning

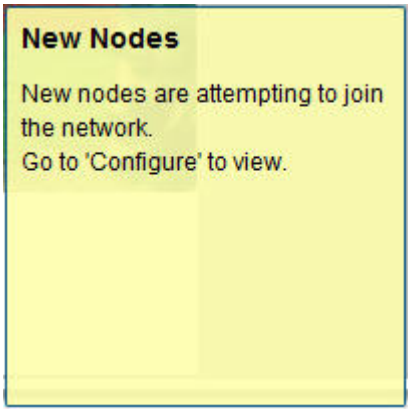
1. Power-up the ēKo gateway and then use your web browser to bring up ēKoView to login. (see Chapter 3).
2. Locate one of the ēKo nodes within 20 feet of the ēKo base radio and press the ON button. You should see the ēKo node scan the sensor ports indicated by 4 red LED flashes (one red LED flash for each unattached sensor). If you had a sensor attached, you should see green LED flash for that port.
3. After the ēKo node finishes scanning the sensor ports, you will see a series of rapid white LED flashes. During this time the ēKo node tries to communicate with the ēKo base radio. Following should be the LED pattern (with no sensors attached) during commissioning process.

LED Sequence	1st Flash	2nd Flash	3rd Flash	4th Flash	Repeated Flashes
LED On Period	2 sec	2 sec	2 sec	2 sec	1 sec
LED Color	●	●	●	●	○ ○ ○ ..... ○
Operation	Scan Port 1	Scan Port 2	Scan Port 3	Scan Port 4	Trying to commission

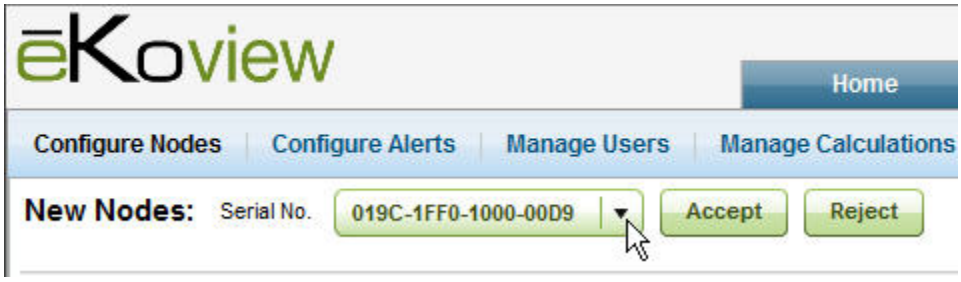
IMPORTANT: The ēKo node needs to be located within the radio range of the base radio during commissioning process.

4.2 Commissioning

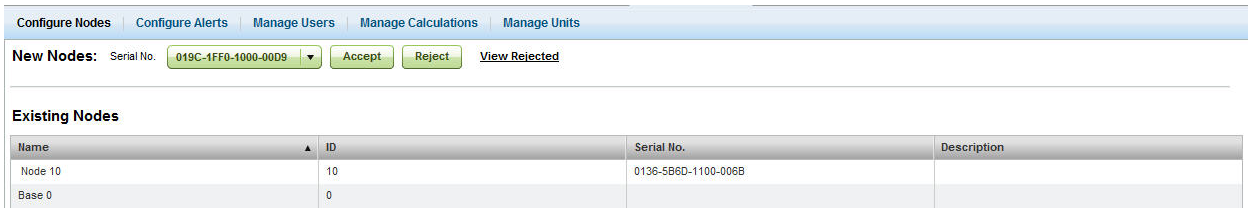
4. When you log into the ēKoView, you will see a notification message at the right bottom of the page saying "New nodes are attempting to join the network. Go to 'Configure' to view". This notification will disappear after about 5 seconds.



5. Go to the Configure tab at the top and click on the "**Configure Nodes**" link. This will bring up the Configure Nodes page. In the serial number drop-down of the "New nodes detected" section, you should see the serial number matching the node that you turned on.



6. Select the serial number that matches your ēKo node and click on the **Accept** button. Now you should see this node disappear from the serial number drop-down and appear in the "Configure exiting nodes" table. Each node gets an incrementing ID auto-assigned by the gateway.



Use the self-stick numbers supplied in the kit to apply the node ID assigned above to the eKo node for the ease of identification later during the field deployment.

7. As soon as you accept the node, you should see a rapidly flashing blue LED for about a minute followed by the yellow LED on for 20 seconds. This indicates that you have one good radio link to the base radio. If you had another ēKo node running close by and connected to the network (already commissioned) you would see a green LED which indicates at least 2 good radio links. Following should be the LED pattern (with no sensors attached) once a node is accepted and commissioned.

LED Sequence	1st Flash	2nd Flash	3rd Flash	4th Flash	Repeated Flashes	Solid On
LED On Period	2 sec	2 sec	2 sec	2 sec	1 sec	20 sec
LED Color	●	●	●	●	● ● ● ..... ●	● 2+ connections ● 1 connection ● No connections
Operation	Scan Port 1	Scan Port 2	Scan Port 3	Scan Port 4	Scanning the network	Results of network scan

IMPORTANT: If you see a red LED, then the ēKo node did not communicate to the base radio. Check that the ēKo base radio's "Power OK" LED is on along with Disk 2 LED of the ēKo gateway.

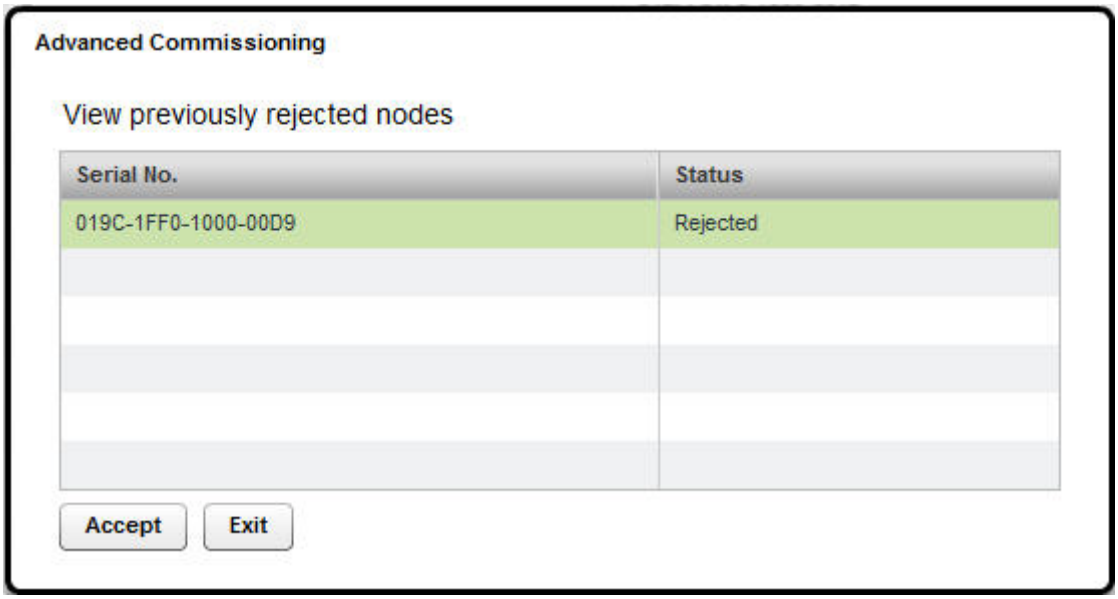
8. Repeat the steps 2-7 for all the ēKo nodes that you have and would like to commission.

NOTE: If you do not accept a node during commissioning the white LED will continue to blink rapidly for about 10 minutes and then the node will turn itself off.

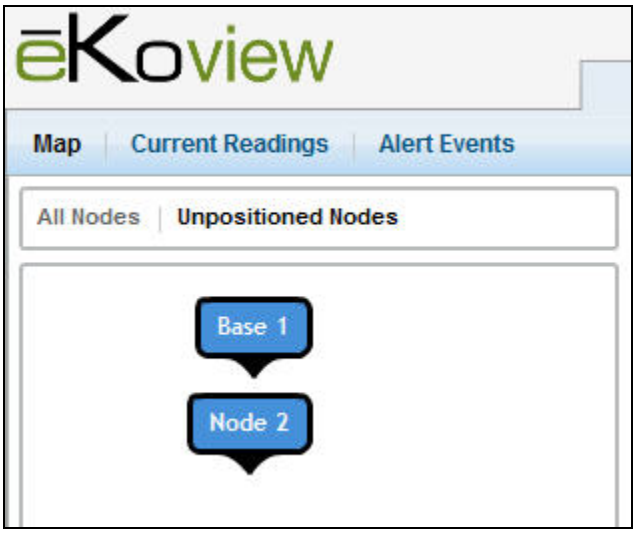
4.3 Post-commissioning

9. After the ēKo node joins the network, it will send data every 30 seconds for the first 60 minutes to allow users to check the sensor data. After this period, the data rate is reduced to one sample every 15 minutes.

10. Turn off the ēKo nodes by pressing the OFF button. The power off status will be indicated by the red LED flash.
11. If a serial number from the drop-down list doesn't match with any of your nodes, you may remove it from your network by clicking on the "**Reject**" button.
12. If you accidentally rejected a genuine node from your network and you want to recover it, you may do so by clicking on the "**View Rejected**" button at the bottom right side of the page. In the Advanced Commissioning dialog window, you can now select and highlight the node that you wish to recover and click on "**Accept**" button.



13. ēKoView allows users to change the name/description of the commissioned nodes. This will allow you to easily identify the nodes when deployed in the field. This can be done later after the node deployment (refer to section 6.4.1).
14. If you go to the Home tab and click on the "Unpositioned Nodes" link on the left side Map panel, you should see the ēKo node icon with the ID of your nodes. The ID should correspond to the one that was noted down on the sticker of the ēKo node.



4.4 Factory Reset Mode:

The ēKo node also provides a factory reset mode, by which all the information stored in the node's memory can be erased (such as node ID, group ID etc assigned during commissioning). To do this, press and hold down the OFF button for about 30 seconds. You will see Red LED come on for about 10 seconds and then start flashing rapidly for about 5 seconds. Then the White LED will come on indicating that the node is ready for factory reset. Release the OFF button, the unit will be factory reset. Following is the LED pattern during the factory reset operation.

LED Sequence	1st Flash	Repeated Flashes	Solid On
LED On Period	10 sec	1 sec	20 sec
LED Color			
Operation	Power-down the unit if OFF button is released.	About to reset to factory defaults	Factory reset when OFF button is released

⚠ WARNING

Never perform factory reset operation when the node is far from the base radio. In order for the node to rejoin the network, it must be re-commissioned by bringing it close to the base radio and following the steps 2-7

5 Deploying the ēKo system

5.1 Deploying the ēKo base radio and gateway

5.1.1 Antennas

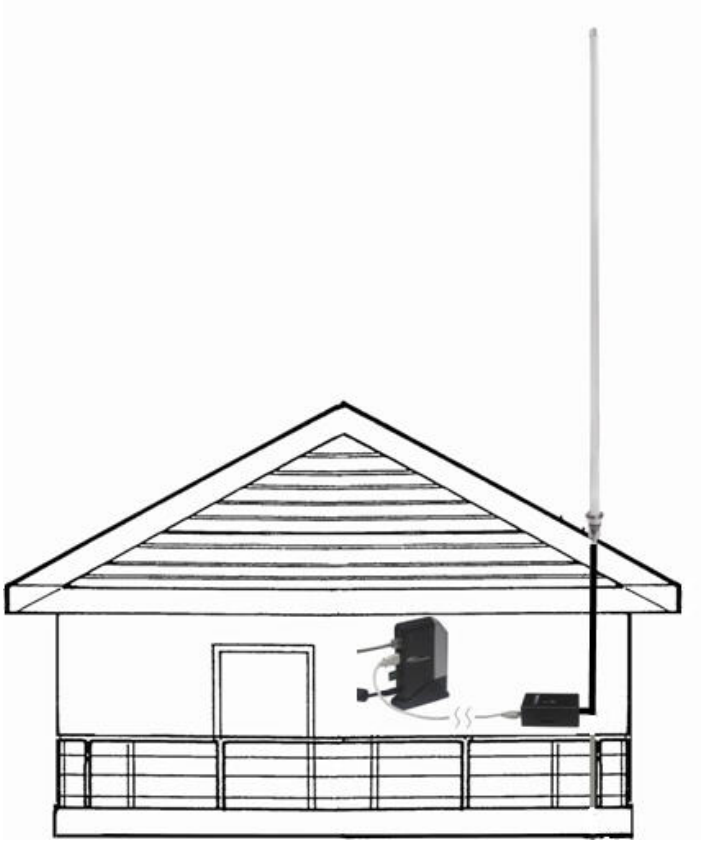
Good radio communication between the base radio and the deployed nodes is important for reliable operation. If there are several ēKo nodes deployed outdoors within a few hundred feet of the ēKo base radio then placing it indoors by a window may be sufficient. However, windows, walls and other barriers can significantly degrade RF communication. Glass windows can reduce the radio range by a factor of two. Mounting the base radio antenna above the roof-line will always improve radio range. Users should consider using a remote, outdoor antenna mounted above the roof line for the best possible communication. If the roof is wood then an antenna mounted indoor, high-up by the roof line may also work. If the roof is metal then an outdoor antenna must be used. Standard outdoor Wi-Fi antennas such as a Hawking's HAO9AI that can be bought at local outlets or online work well. When using these antennas be sure to use the manufacturer's recommended connecting cables otherwise the radio signal may be severely attenuated. The eB2110 ēKo base radio comes with a 2.4 GHz Wi-Fi antenna that can be unscrewed from its reverse SMA connector. This connector should be compatible with the external antenna coupling.

Several options are available for configuring an external antenna, the placement of the base radio and its connection to the gateway:

1. **Standard Indoor Antenna**: Use the standard ēKo base antenna (the antenna that comes with the ēKo base radio) and mount the ēKo base radio on an inside window or window seal. The ēKo gateway can be placed within 8' of the base which is the length of the USB cable connecting to the gateway.

2. **High-gain Indoor Antenna**: Helps improve the radio range of the base. The base radio is typically mounted on an inside window or window seal. An omni/directional indoor antenna should be used for better range.

3. **High-gain Outdoor Antenna**: Mount an outdoor omni/directional antenna above the roof line. Use an RF extender cable to connect to the ēKo base. The ēKo base radio and ēKo gateway can be located near the router or remotely in attic using a PoE adapter.



The Table 5-1 summarizes the features of each of these options.

Table 5-1. Features of the different antenna configuration options

	Standard		High-gain Indoor		High-gain Outdoor	
Cable connection lengths						
Antenna distance to the base radio	0 ft		3 ft		3-50 ft	
RF Gain and Range						
	Gain	**Range**	**Gain**	**Range**	**Gain**	**Range**
Standard	0 dBi	1 x				
Omni- directional			6 dBi	2 x	15 dBi	3 x

⚠ WARNING

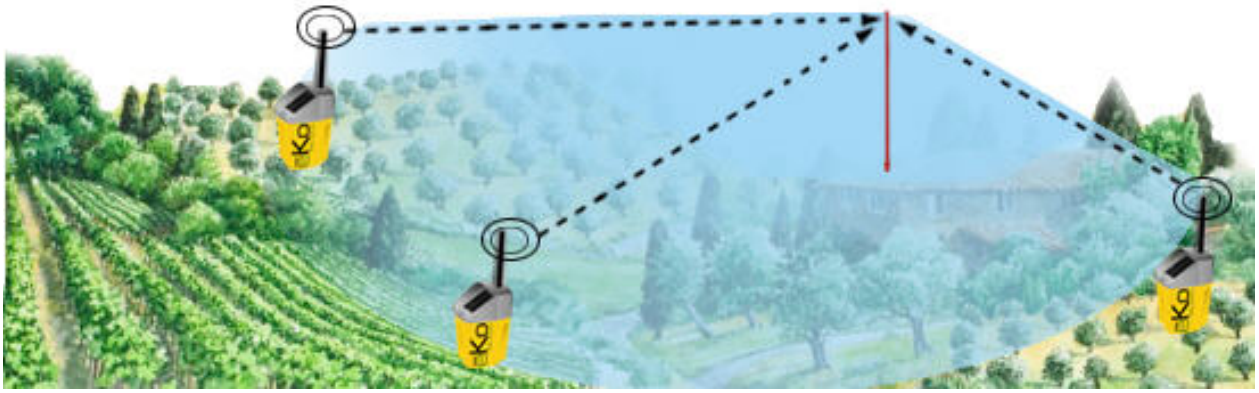
When using outdoor mounted antennas all cables must be connected via a lightening arrestor to a solid earth ground for protection against lightening. Failure to do so may result in a serious safety hazard.

Using an External Omni-directional Antenna:

These antennas (eg. Hawking HAO9SIP) usually provide about a 9dBi gain which will improve the ēKo base radio range by a factor of two. The RF beam is focused to about ±15 degrees from the horizontal plane.

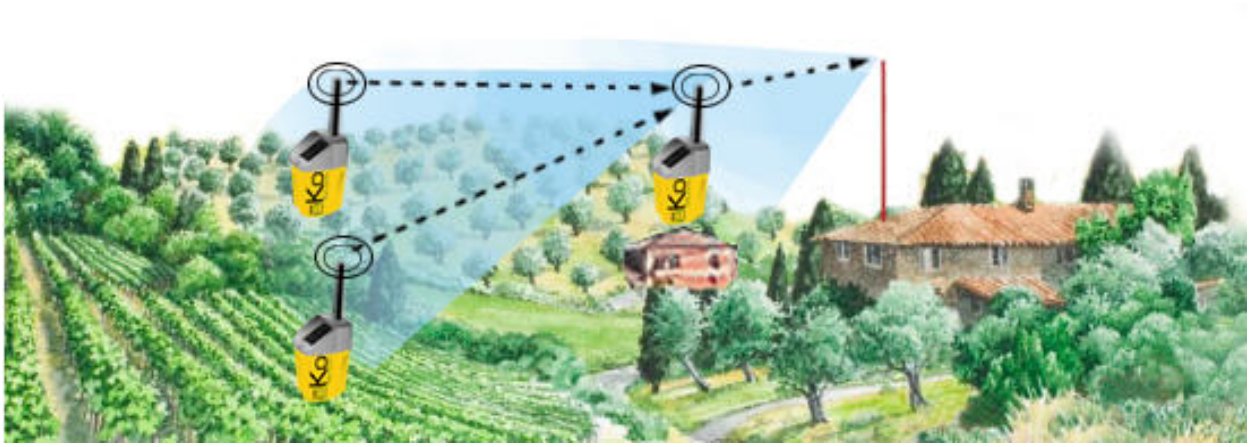
Figure 5-1. Photo of the external Omni-directional antenna kit (Hawking HA15SIP)

The antenna should provide good 360^0 coverage when mounted externally. Be careful of the ēKo nodes units mounted directly below the antenna as the antenna focus's the energy to ±15 degrees from the horizontal plane.



Using a Repeater Node:

If the ēKo base radio is located remotely from the nearest ēKo node, it may be necessary to use some of the ēKo nodes as repeaters. Any unit can be used as a repeater with or without sensors. An example is shown in the picture below where there is another facility between the network and the ēKo base radio.



5.1.2 UPS

For high reliability consider a UPS (battery backup) to keep the gateway powered during power outages. The ēKo gateway is a low power device that only consumes about 4 watts of power. A low cost UPS such as the APC 325VA (http://www.apc.com/) can supply battery back-up power for approximately 4 days. When choosing a UPS device it is highly recommended to pick one that provides Status notification via USB. The ēKo gateway has a preinstalled driver that is compatible with respective APC UPS devices. See section 7.6 for details on such a setup.

Figure 5-2. Photo of the UPS back-up for gateway (from APC)

5.2 Deploying ēKo Nodes

Placing the ēKo nodes properly in the field is critical for reliable networking and operation. Use the following guidelines:

- If possible, place the ēKo nodes at least 5-12 feet above the ground. Radio range will be reduced as the units are placed lower to the ground.
- A clear line-of-sight between units is preferable. Trees, foliage, and canopies that are higher than the antennas will reduce radio range. The Figure 5-3 shows a correct installation and one that will experience RF degradation due to canopy coverage.

Figure 5-3. Photo of the ēKo node installations (Left: Correct; Right: Incorrect)

- For some crops like orchards with tall canopies but some clearance to the ground the units can work at 3 feet above the ground between the bottom of the canopy and ground.
- Units require about 1-2 hours per day of sunlight exposure to keep their batteries charged.
- The enclosures have a metal bracket on the back that can be used to secure the units to stakes.

Figure 5-4. Photo of the ēKo node mounted on to a stake

The reliability of the network depends on multiple radio connections. If the radio communication from one ēKo node to another degrades due to interference, the transmitting ēKo node will automatically route to another ēKo node within its radio range. This means that all units should have at least two good radio paths to their neighbors or base radio at all times. ēKo nodes have a unique algorithm (patent pending) to determine the available radio paths during installation. When the ēKo node is powered by pressing the ON button, node scans the sensor ports indicated by 4 red LED flashes (one red LED flash for each unattached sensor). If you had a sensor attached, you should see green LED flash for that port. It will then enter a network search mode and signal nearby ēKo nodes and/or the ēKo base radio to find out how many good radio paths are available. This takes about 1 minute each time the ON button is pressed. The LED at the bottom of the unit displays the status followed by the quality of the radio paths discovered (see Table 5-2):

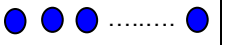
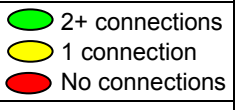
Table 5-2. LED status indicators for the ēKo node

Port Scan Mode	Description
Red flashing	No sensor was detected at that port
Green flashing	Sensor was detected at that port
Network Search Mode	Description
Rapid blue flashing	This pattern starts each time the ON button is pressed and after the sensor port scan is complete. The node is searching for nearby nodes to determine the quality of the available radio paths. After one minute, the blue flashing will stop and a color (see below) will be displayed for 20 seconds.

After the search is completed one of the following patterns will be displayed for 20 seconds.

Connection Status	Description
Solid red	No radio paths have been found. Move the location of the node or place a repeater node.
Solid yellow	One good radio path found. If there is only one node in the network then this is OK however there will be no alternate radio paths to the base radio.
Solid green	Two or more solid paths found. The node is in a good position.

Following should be the LED pattern during deployment phase (with no sensors attached) when the ON button is pressed.

LED Sequence	1st Flash	2nd Flash	3rd Flash	4th Flash	Repeated Flashes	Solid On
LED On Period	2 sec	2 sec	2 sec	2 sec	1 sec	20 sec
LED Color						 2+ connections 1 connection No connections
Operation	Scan Port 1	Scan Port 2	Scan Port 3	Scan Port 4	Scanning the network	Results of network Scan

5.2.1 Deploying the Network

Usually the network is established by placing the first ēKo nodes close to the base radio and then working outwards.

☑ EXAMPLE

1. Place the first ēKo node in the network at a position that is within good range of the ēKo base radio and press ON button. This will give a yellow LED indicator when placed correctly as there is only one radio path back to the base radio.
2. Place the second ēKo node within radio range of both the base and the first ēKo node and press ON button. When placed correctly, this will give a green LED indicator.
3. Continue to expand the network outwards from the base, trying to maintain the green LED indicators.

IMPORTANT: If you see a red LED indicator, move the node location within the RF range of at least one other ēKo node until you see a yellow or green LED indicator.

Deploying in Flat Terrains

The Figure 5-5 is from a tree nursery site. Four units are spread over approximately 100 acres. This terrain is very flat, the crop low to the ground (<24 inches) and the units installed on poles 6-8 ft above ground. RF coverage is about one node per 25 acres.

Figure 5-5. Example deployment in flat terrains

Deploying in Hilly Terrains

Hilly terrains, as typically found in vineyards, result in large variations of radio ranges due to altitude changes and foliage. Figure 5-6 is a picture of a deployment done in a vineyard in Napa, California. Radio range between ēKo nodes mounted about 8 ft above ground in the vineyard range from 300 to 700 ft typically (eg. nodes 501, 506). ēKo nodes that are located with some elevation relative to other units and clear line-of-sight can achieve ranges of upto 2000 feet (eg. node 504).

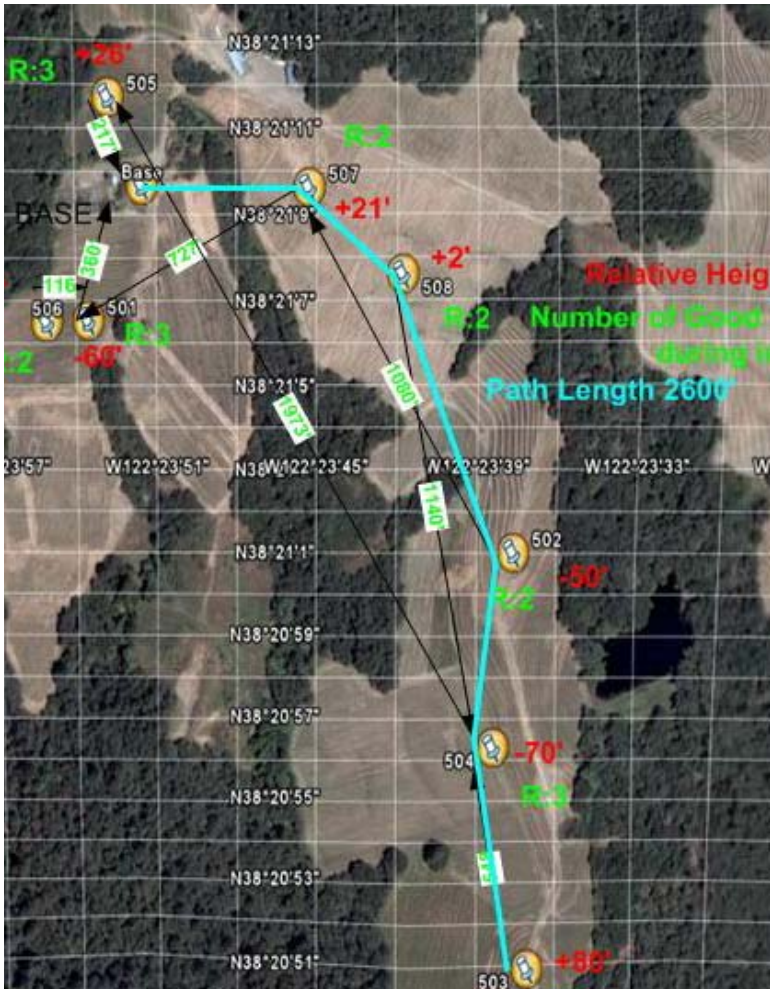


Figure 5-6. Example deployment in hilly terrains

Deploying in Orchards

Orchard deployment will usually require repeater nodes due to RF attenuation of the dense foliage. The Figure 5-7 shows the single-hop radio range in a walnut orchard which is about 200 feet. For this deployment the ēKo nodes are placed about 3 feet above the ground but below the foliage. Users should consider about one ēKo node per acre for good RF coverage.

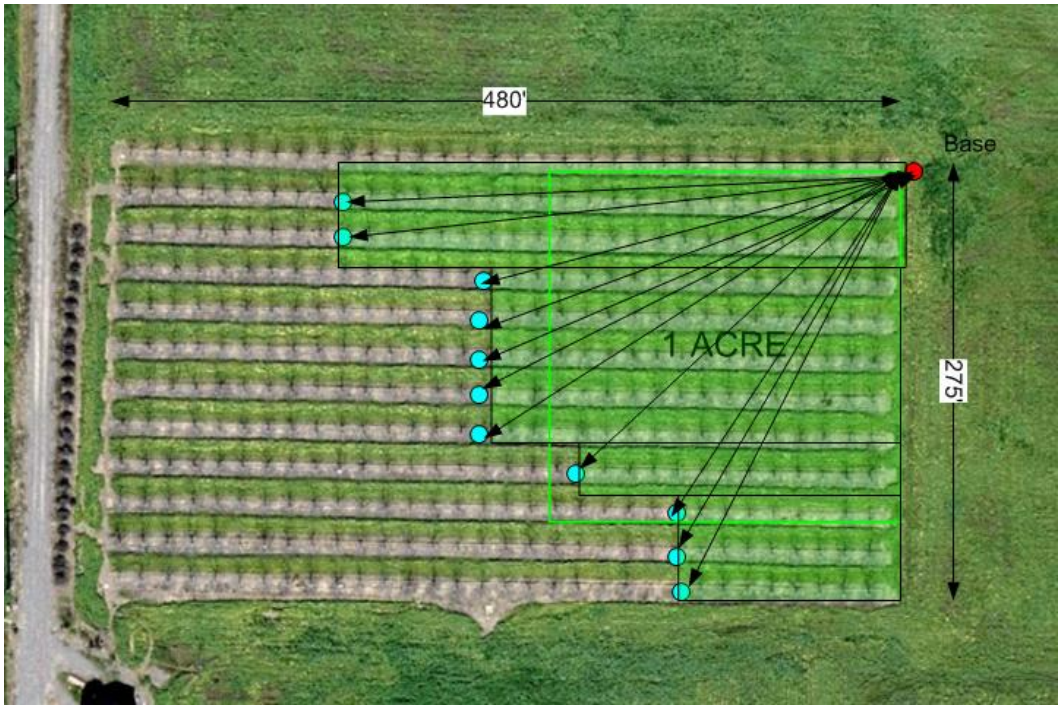


Figure 5-7. Example deployment in orchards

IMPORTANT: Normally after deploying the network, users should monitor the network for a few hours before burying soil sensors in case the node needs to be moved or another node used as a relay. (See section 6.5.1). If the yield is less than 85%, refer to the section 6.5.2 before proceeding to the next section on attaching the sensors.

5.3 Deploying ēKo Sensors

Presently ēKo Pro series system supports five external sensors and one internal set of sensors:

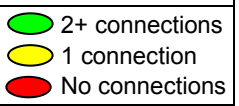
- eS1101 external soil moisture and soil temperature sensor. Both sensors are attached to a single ēKo node connector
- eS1101 soil water content sensor
- eS1201 external ambient temperature and humidity
- eS1301 leaf wetness sensor
- eS1401 solar radiation sensor
- Internal sensors in the node which measure:
    - Battery voltage
    - Solar voltage
    - Enclosure temperature

5.3.1 Connecting Sensors to the ēKo Node

Users can connect sensors easily and within a few seconds. All ēKo compatible sensors are self-identifying via a built-in identification scheme.

1. Connect the switchcraft connector on the sensor to the one of the available ports on the ēKo node. You can latch it securely by twisting the lock ring around the connector.
2. After a sensor is attached and the ON button is pressed, it scans all four sensor ports for attached sensors.
3. It will flash either red (no sensor attached) or green (sensor attached) for a port. The node scans port 1 first then port 2, 3 and finally port 4. There will be four flashes, one for each port and each flash will be red (no sensor attached) or green (sensor attached).

Following should be the LED pattern during deployment phase (with sensors on Port 2 and Port 3) and the ON button is pressed.

LED Sequence	1st Flash	2nd Flash	3rd Flash	4th Flash	Repeated Flashes	Solid On
LED On Period	2 sec	2 sec	2 sec	2 sec	1 sec	20 sec
LED Color						
Operation	Scan Port 1	Scan Port 2	Scan Port 3	Scan Port 4	Scanning the network	Results of network Scan

IMPORTANT: Any time a new sensor is attached the ON button must be pushed in order for the node to recognize the sensor.

5.3.2 Installing the Sensors

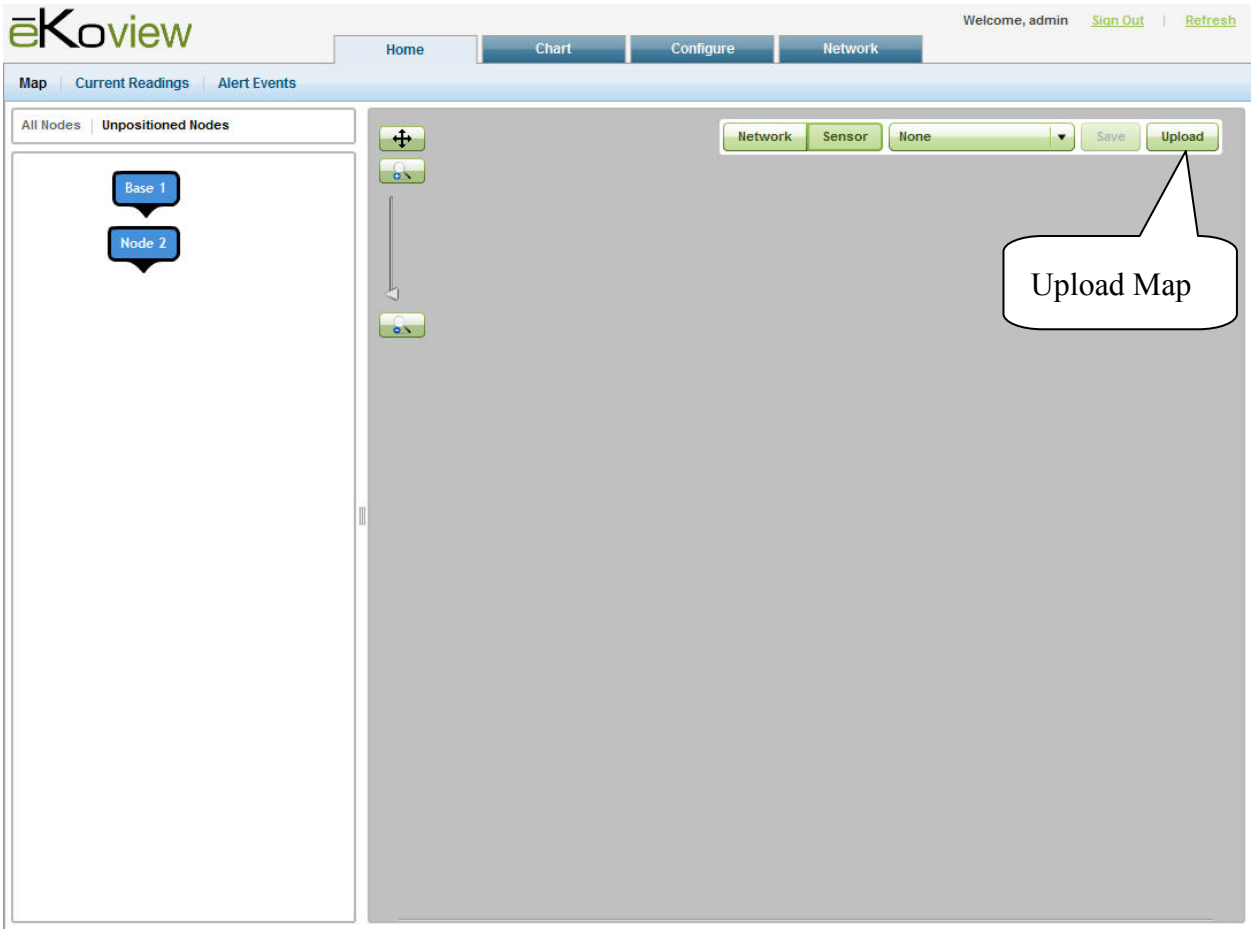
Refer to Chapter 8 for installation instructions for different sensors.

5.4 Configuring ēKoView

5.4.1 Uploading a background map

ēKoView allows users to upload a jpeg map file of the deployment area. This will show up in ēKoView's Map page and is useful to locate where the sensor nodes have been placed.

1. The first step is to create a jpeg image file of the area. This can be done by importing a picture into Window's Paint program and storing the image as a .jpeg.
2. You can access this page by clicking on the **Map** link of the Home tab.
3. Click on the **Upload** button at the top right of the Map page.
4. Navigate to the jpeg map file on your PC and click on **Open**.
5. The next time ēKoView starts you should see this map in the Map view (depending on your browser settings, you may need to close your browser).

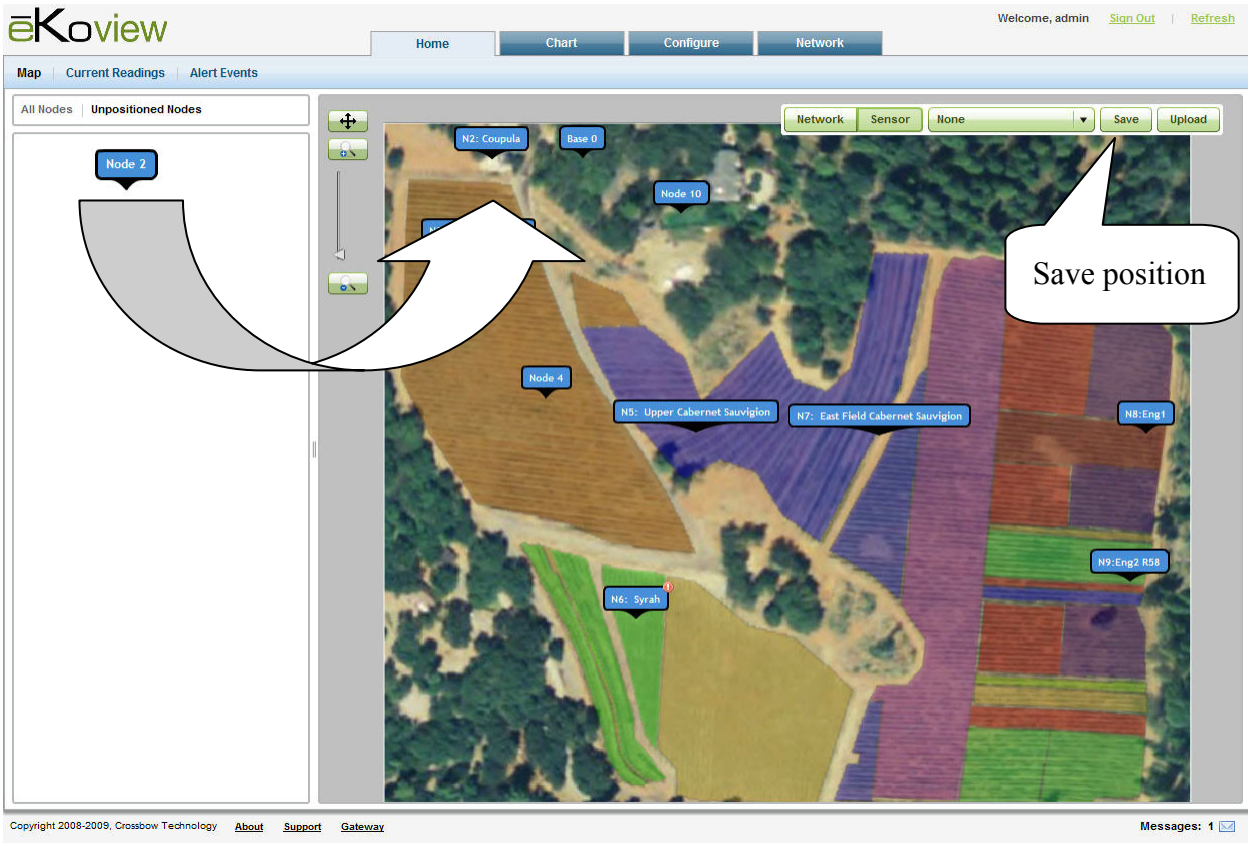


5.4.2 Positioning commissioned nodes

As new nodes are commissioned into the network, they will appear in the Un-positioned Nodes box on the left hand side Map Panel. To position a node onto the Map, click and drag the node from the un-positioned box to its location on the Map.

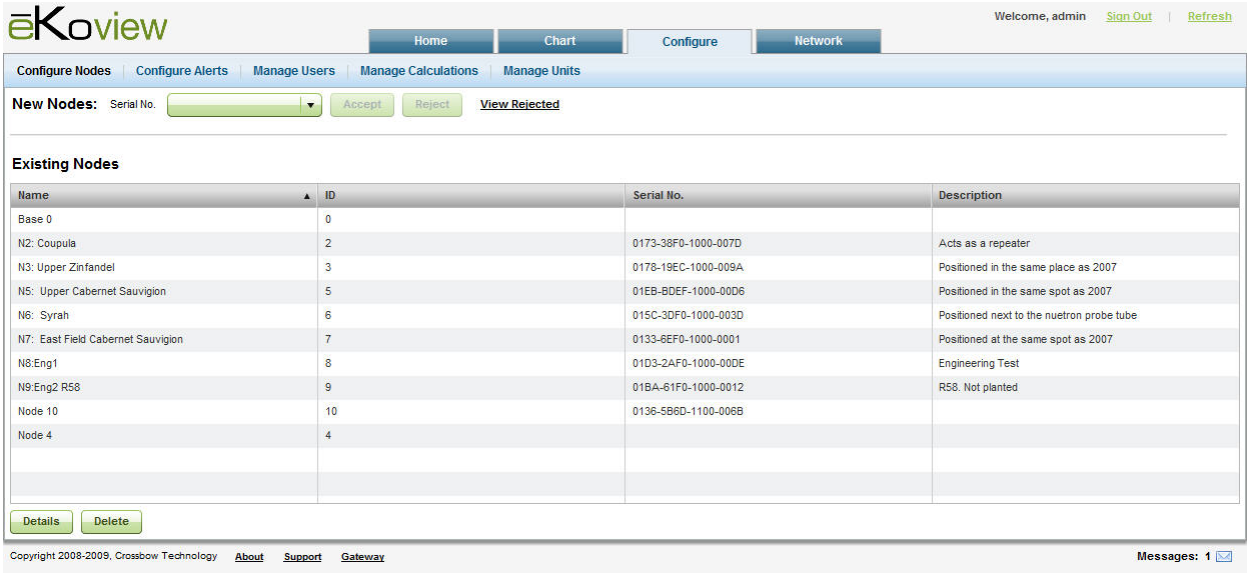
Once you have positioned all the nodes on the map, press the **Save** button on the top right of the screen to save your changes back to the server.

If after positioning nodes, you decide to rollback to the original positions instead of saving the changes, press the **Refresh** button on the top right.

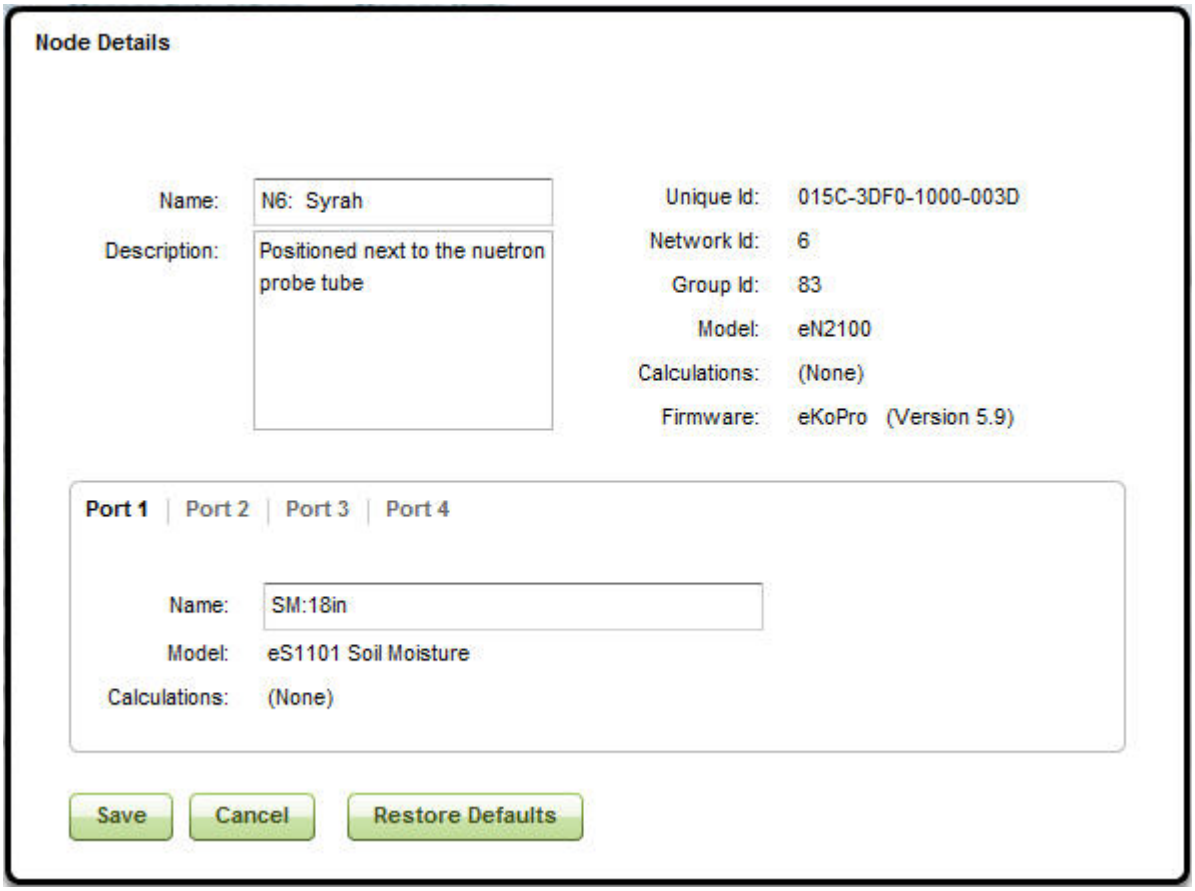


5.4.3 Configuring the nodes and sensors

When data from a new ēKo node first appears at the gateway, the ēKoView will give the node and its attached sensors pre-assigned names. The node will be labeled as 'Node xxx' where xxx is its network address (same as ID of the node). An eS1101 ēKo sensor name will be defaulted to "eS1101 Soil Moisture: Port x" where x is the port number of the ēKo node that the sensor is attached to. ēKoView allows users to rename both the node and sensor. You can access this page by clicking on "**Configure Nodes**" button in the Configure tab. The commissioned nodes will appear in the "Configure existing nodes" list.



Select and highlight the node you wish to reconfigure and click on the "**Details**" button at the bottom of the page. It will bring up the "Node Details" dialog window. Edit the name and description as you wish and then click on the **Save** button.



6 Data viewing using ēKoView

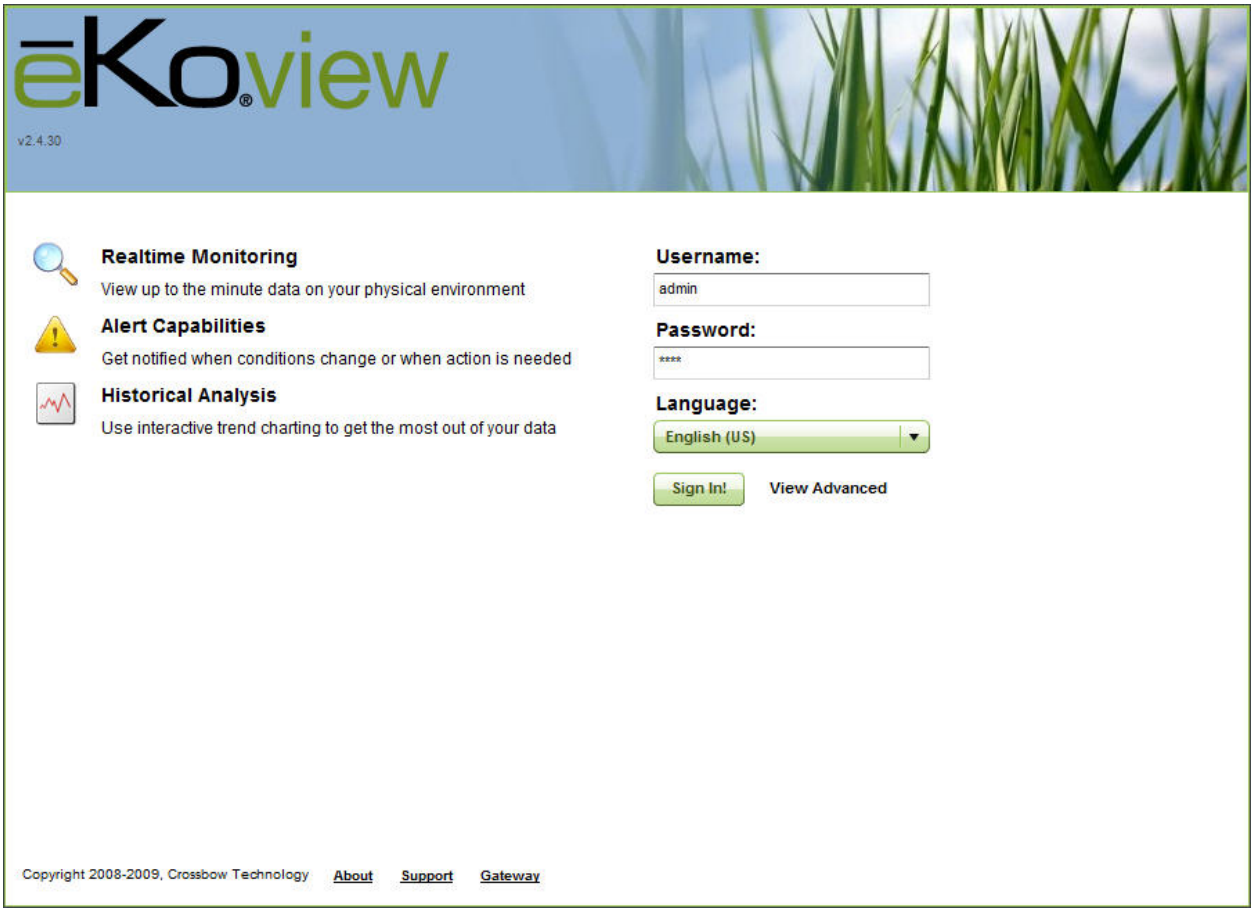
This section describes the features of the ēKoView web interface provided with the ēKo Pro Series system. ēKoView is a web-based sensor network data visualization application.

6.1 Login Page

To login to ēKoView

- Open a web browser on your PC
- In the URL field type *http://eko-xxxxx*

(where xxxxx is the serial number written on a sticker attached to the bottom side of the device)



NOTE: If you're using a home network router or can't login with using the name on the sticker, use the GatewayFinder tool from your installation CD to find the IP address of your ēKo gateway (refer to section 7.1).

ēKoView requires a username and password to login. The default values are:

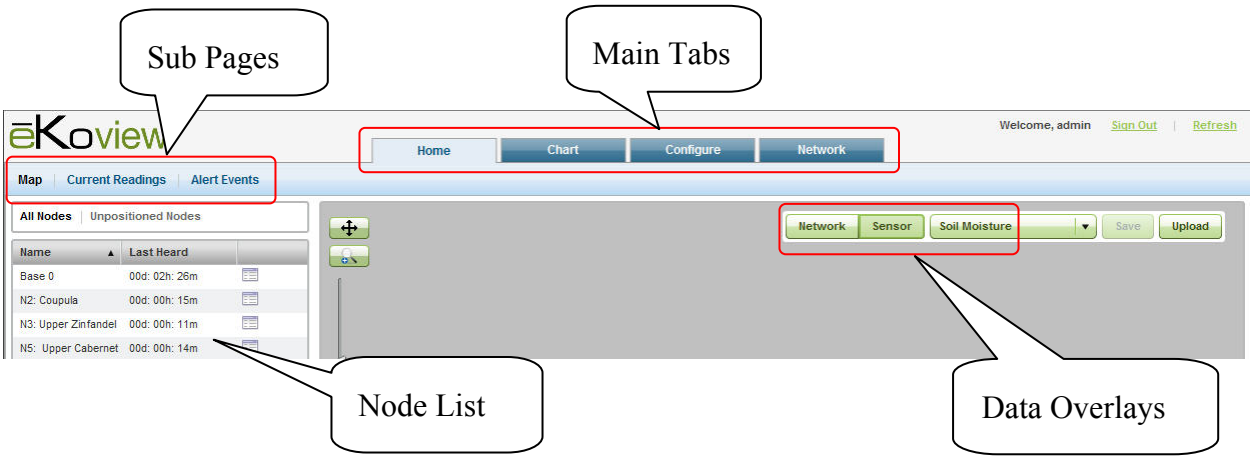
Username: admin

Password: crossbow

The default user password can be changed using the Manage Users page (refer to Section 6.4.3)

ēKoView has four main user interface sections which you can browse and use.

- **Home:** Shows a node network map with placement and parenting information, sensor dashboard for quick glance of sensor data and list of most recent alerts.
- **Chart:** Provides the ability to generate graphs of a sensor data vs. time for a set of nodes.
- **Configure:** Allows for commissioning of the new nodes, configuring node details, configuring alerts on the data and managing users in the system.
- **Network:** Displays the latest health packet readings and statistics received for each node in the network.



NOTE: To view the tool tip information, move and place your mouse cursor over a specific tab or button and a brief description will appear describing the functionality.

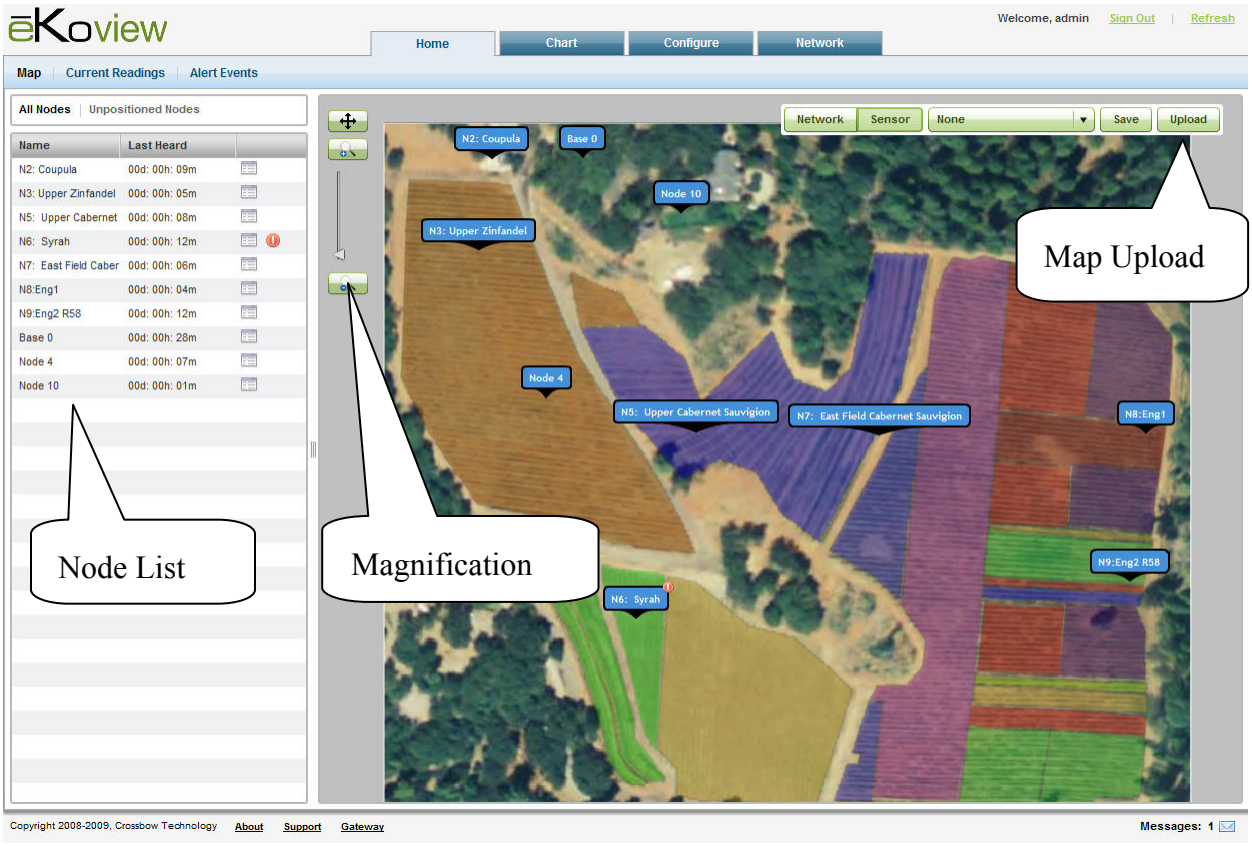
IMPORTANT: Do not use Refresh/Reload buttons in your web browser to refresh the page (use **Refresh** link on the top right hand side instead). Should you accidentally use these buttons, then you will need to login back into ēKoView.

6.2 Home Tab

This tab shows a node network map with placement and parenting information, sensor dashboard for quick glance of sensor data and list of alerts.

6.2.1 Map Page

ēKoView provides users will a mechanism to visualize sensor data relative to a user provided map. You can access this page by clicking on the **Map** link in the Home tab.



6.2.2 Uploading a background map

ēKoView allows users to upload a jpeg map file of the deployment area. This will show up in ēKoView's Map page and is useful to locate where the sensor nodes have been placed. Refer to the previous section 5.4.1 for more details on this.

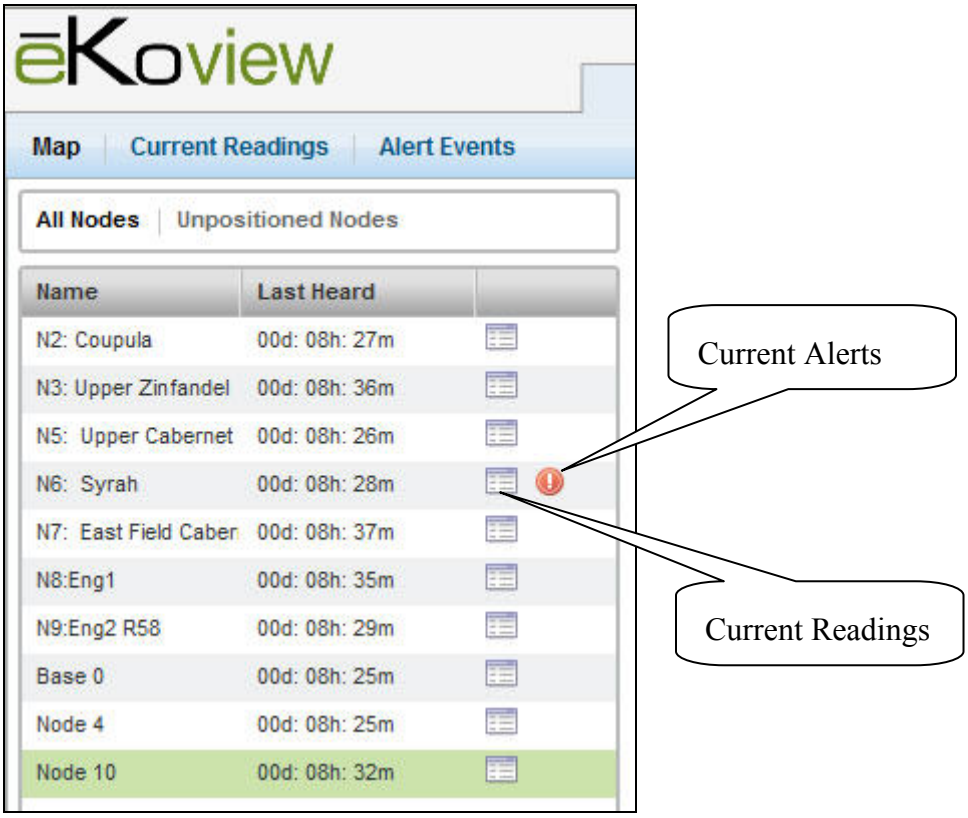
6.2.3 Positioning the nodes

As new nodes are detected in the network they will appear in the Un-positioned Nodes box on the left hand side Map Panel. To position a node onto the Map, click and drag the node from the un-positioned box to its location on the Map. Refer to the previous section 5.4.2 for more details on this.

NOTE: You will need admin privileges to upload map or move the position of the nodes. If you are not logged in as "admin", **Save** and **Upload** buttons will be disabled for you.

6.2.4 Node list

The node list in the left hand side Map Panel provide a quick snapshot of all the nodes commissioned into the network. It provide a list display of Node name, last heard time and latest readings and alerts. To view current readings, move the mouse cursor and hold it over icon. To view current alerts, move the mouse cursor and hold it over icon. If you want to locate a specific node on the map, just click on the node name from the list and the corresponding node will flash on the map.



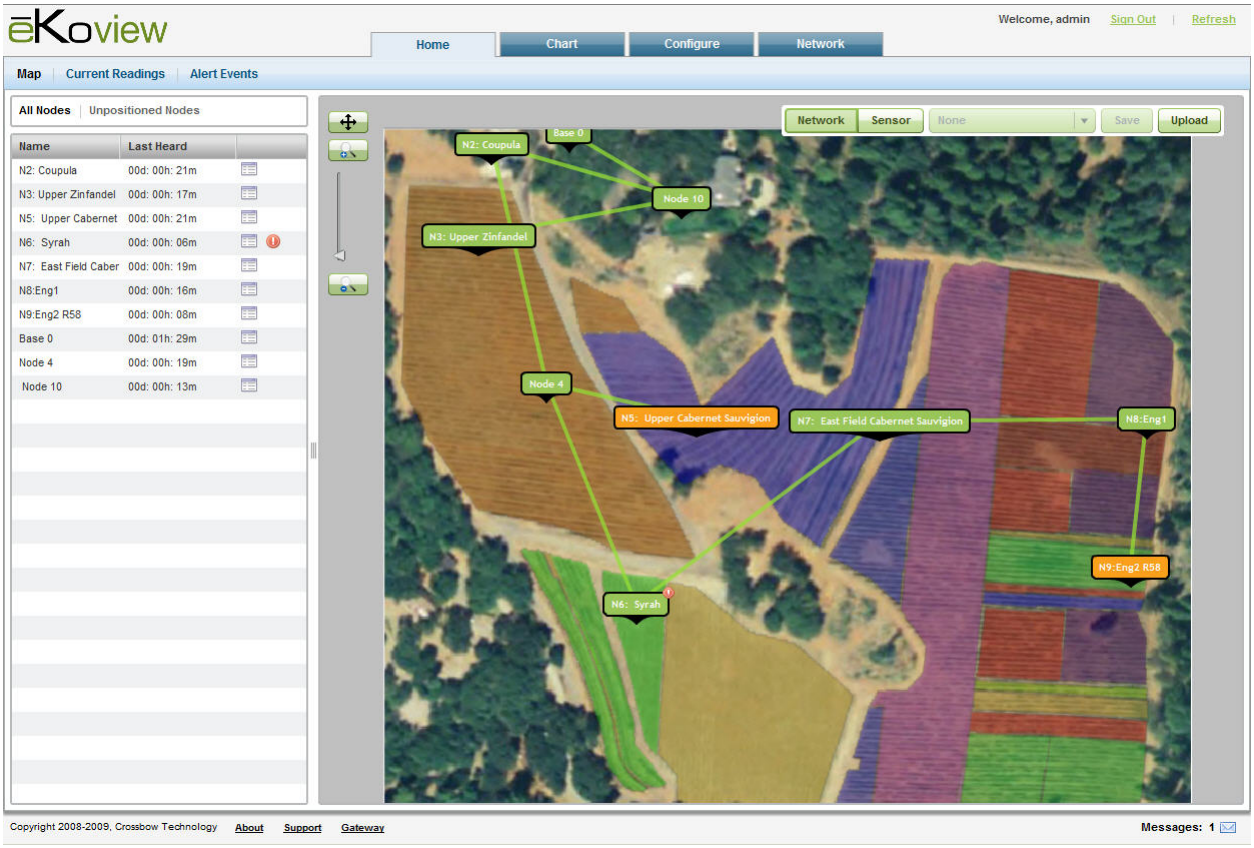
6.2.5 Data overlays

The Map page allows you to see two different types of data: Network Data and Sensor Data.

Network Overlay

When on the network data overlay users will see network routing information for each node. To view the network data overlay, click on **Network** button at the top right of the map page. Initially users will see node parent and route information visually. Each link represents a parent child relationship. The color of the link indicates its quality. Link Quality Indicators are:

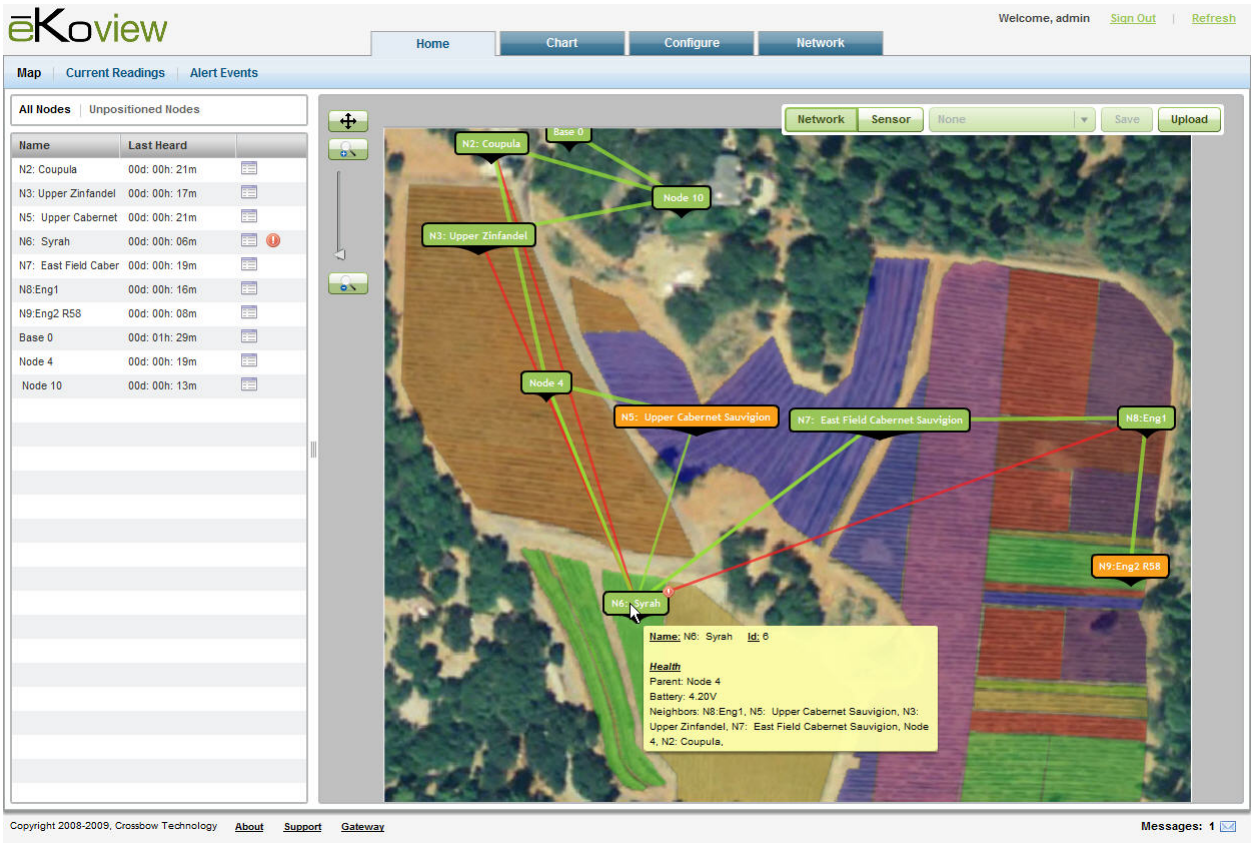
- Green – Both incoming and outgoing links are over 90%
- Orange – Either one or both of the incoming or outgoing links is between 90% and 40%
- Red – Either one or both the incoming or outgoing links is below 40%



The color of the nodes indicates how many potential good neighbors a node has. Node Neighbor Quality Indicators are:

- Blue – Node has more than two neighbors with Green link quality
- Orange – Node has only one node with Green link quality
- Red – Link has no nodes with Green link quality

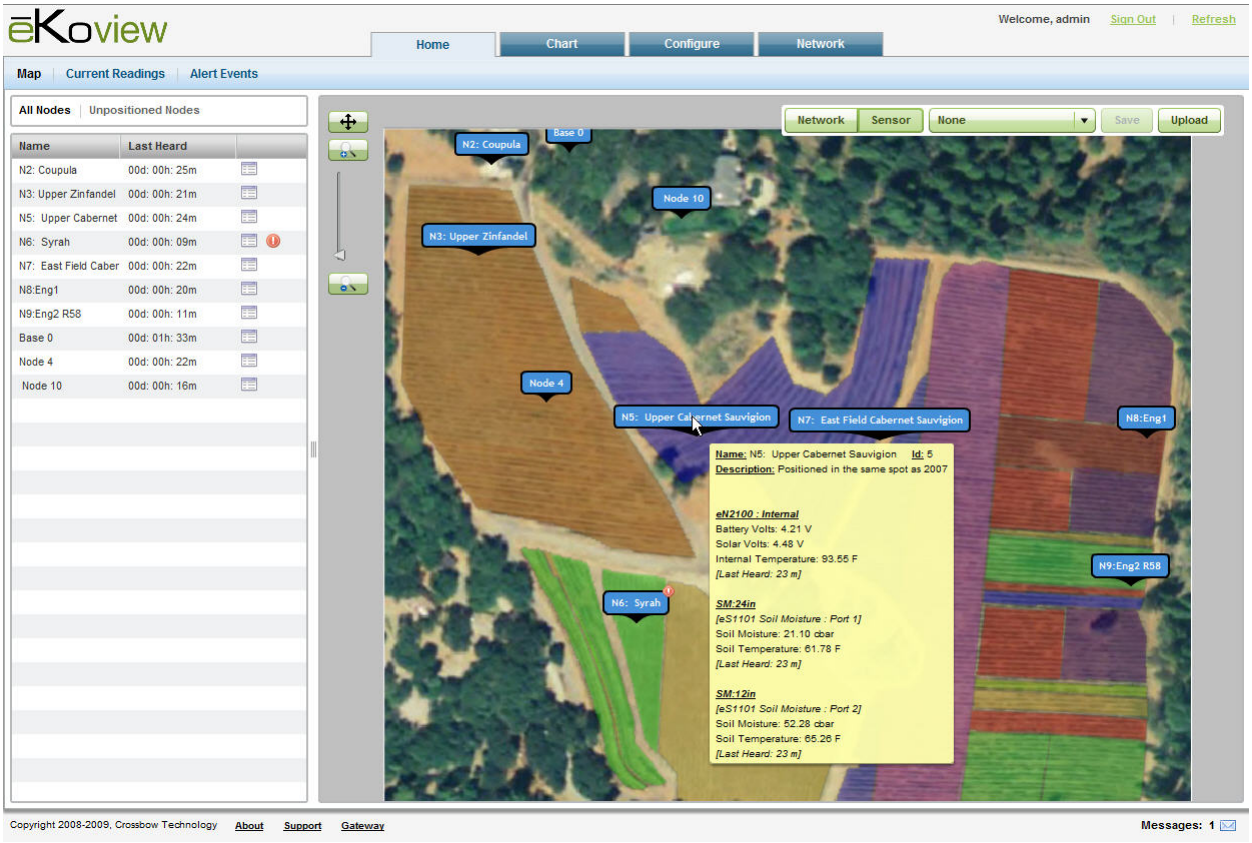
The Network Overlay also allows you to see the nodes neighbors visually as well as the nodes network information including its parent, route, neighbors, and battery voltage. To view this information, move your mouse over a node and pause for a second.



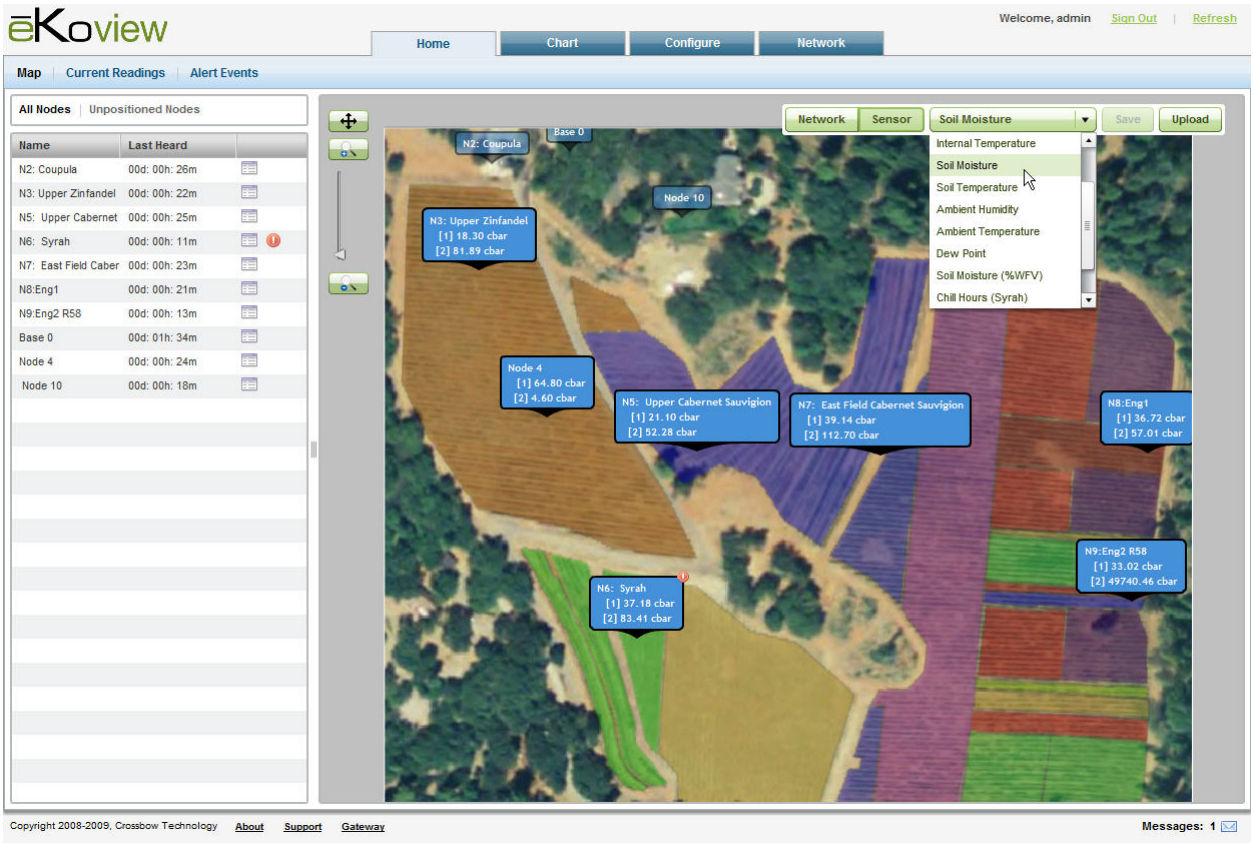
Sensor Overlay

When on the sensor data overlay users will see the most recent sensor data from each node. To view the sensor data, click on **Sensor** button on the top right of the map view, place your mouse over the node and wait a second. A pop-up with the sensor data will appear.

The color of the nodes will appear blue.



Sensor Overlay also allows you to see the sensor data from all the associated nodes visually on the map. To view this information, choose a sensor from the drop-down box. The digital sensor value will appear next to each of the nodes that have selected sensor attached to them. Also shown in the brackets is the port number associated with the selected sensor for any applicable node (0 represents ēKo node's internal sensor). The color of the nodes that don't have the selected sensor type will turn into faded blue.



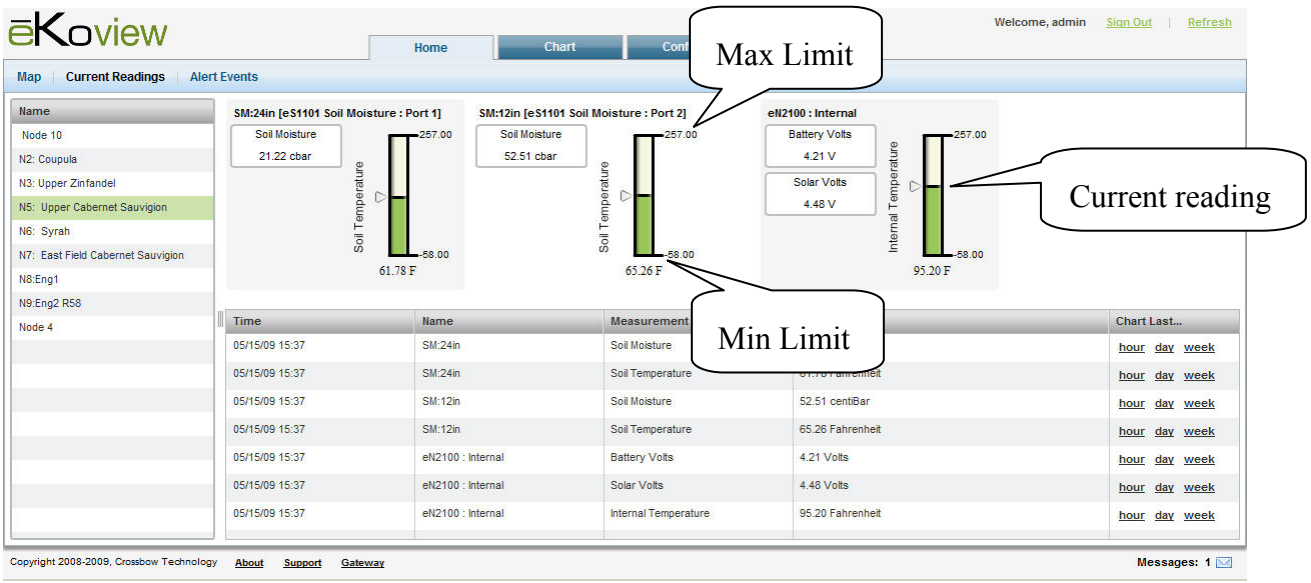
6.2.6 *Current Readings Page*

This page shows sensor data from any given node in the form of dashboard and tabular data. You can access this page by clicking on the **Current Readings** link in the Home tab. You can select the node to view by selecting the node name from the Node List on the left hand side panel.

In the dashboard view at the top, all the sensors associated with the selected node are displayed in the form of bar chart. The maximum and minimum sensor limits are displayed at the top and bottom of the bar respectively and the current sensor reading is shown relative to these by a grey line and a digital display. Similarly, the alert threshold (if configured) is shown in the red text. If there is an active alert associated with any sensor, the bar graph would turn red and display the alert threshold.

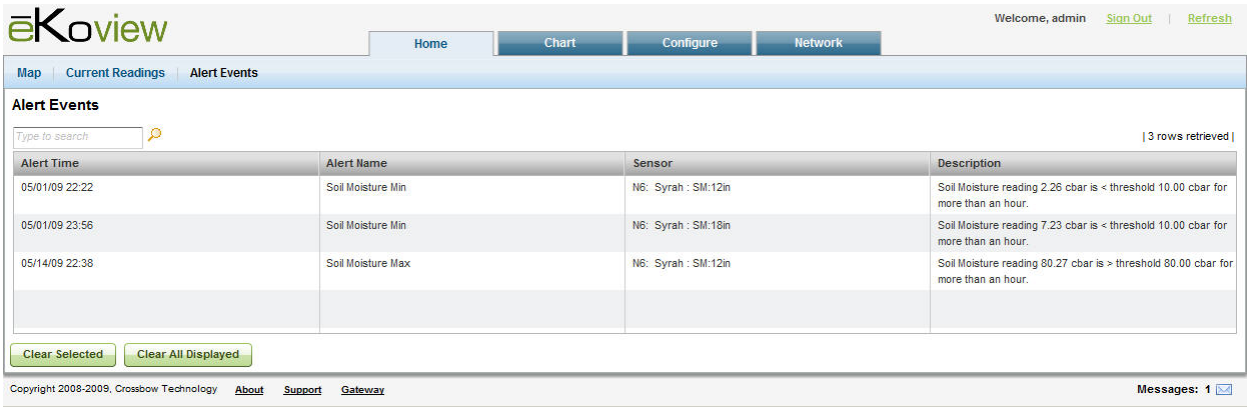
In the tabular view at the bottom, all the sensors associated with the selected node are displayed in the form of a table. From here, you also have a quick links to Chart data from a specific sensor during last hour, last day or last month.

◀ **NOTE:** When you are in any tabular view, left-clicking the column header allows you to sort data by that field.



6.2.7 *Alert Events*

This page displays the most recent alerts from all nodes in the form of tabular data. You can access this page by clicking on the **Alert Events** link in the Home tab.



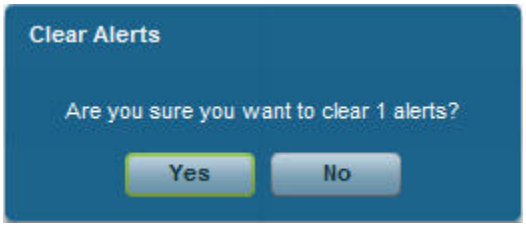
To search for a particular set of alert, users can type a search string into the top left search text box. As users type the string, the table attempts to match rows which contain that search string and filters out the results.

Clearing Alerts

Once you have seen an alert and taken action on it, you may clear it from the Alert page. This will also reset the color of the node from Red to Blue in the Alert Overlay of the map page. The Alerts can be cleared from the Alerts page using the buttons provided on the lower left side of the screen.

- **Clear Selected** – clears only highlighted alerts (you may select multiple alerts by using **Shift** or **Ctrl** keys)
- **Clear All Displayed** – clears all the alerts displayed in the given view (which can be narrowed down using the Search string)

In the "Clear Alerts" confirmation dialog, click on "**Yes**". The alert will now disappear from the alert page.



☑ EXAMPLE

A user wants to clear all Temperature alerts from the list. In the search box type "Temperature" and only the Temperature sensors will be displayed. Then click on "**Clear All Displayed**" button.

If you are logged into the ēKoView, when the alert is triggered, a new alert notification window appears at the right bottom side of the page. This notification will disappear after about 5 seconds.

6.3 Chart Tab

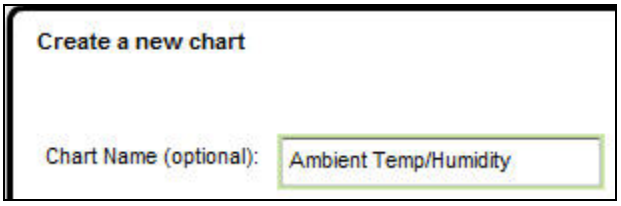
With many sensor network applications, it is important to view data trends over time. ēKoView allows users to visualize data trends through advanced charting tools.

Users can create new charts, modify existing chart, load saved charts, and save/delete chart configurations.

6.3.1 Creating new charts

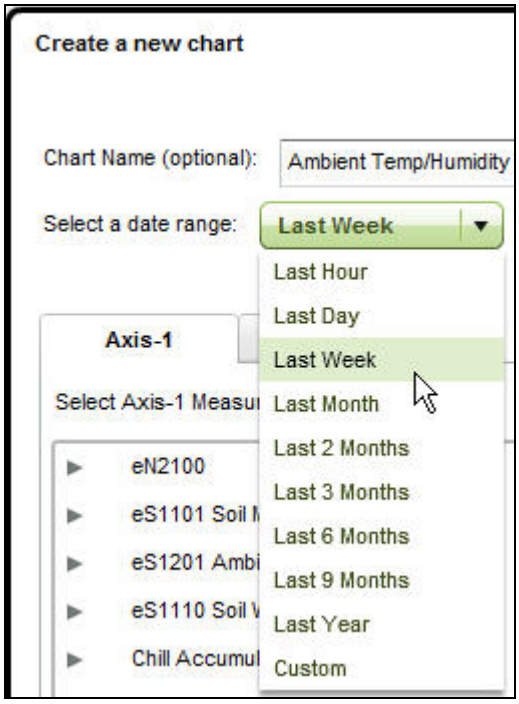
After clicking on the **New Chart** button, the user is shown a charting wizard to help them create a new chart. Users can specify the following:

1. **Chart Name**: Allows to type in a user defined name for the chart (optional).

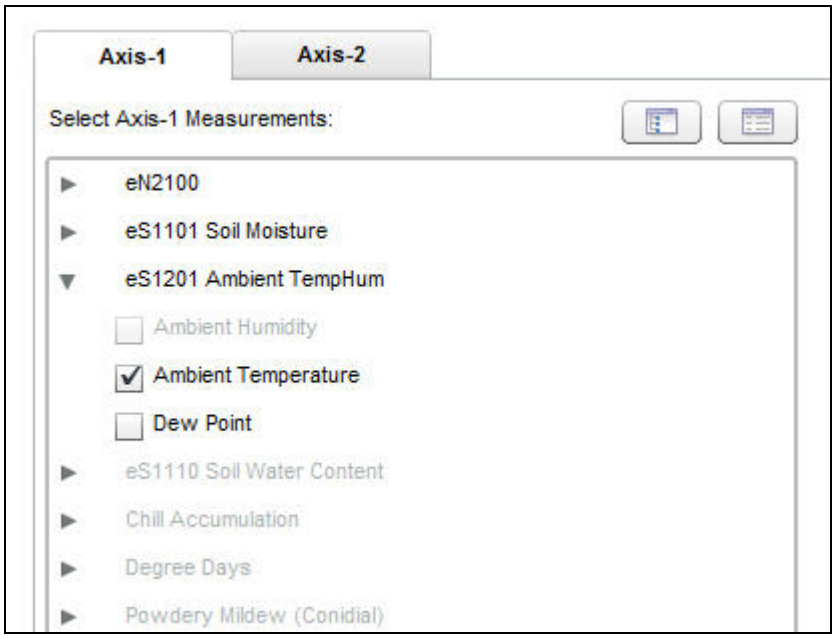


2. **Date range**: Plots data over different time ranges from the drop-down box. ēKoView records all received sensor data into a local database. Data is also aggregated (averaged)

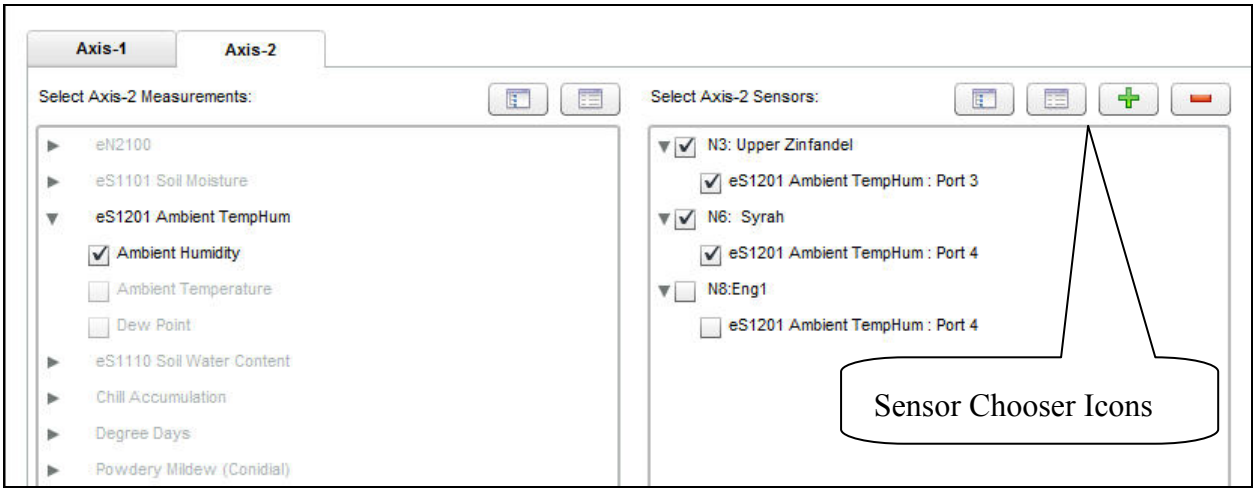
over time to reduce plotting time over long time spans. Data is averaged over hourly, daily and weekly time periods. The user can also specify the custom date range by choosing the **Custom** date range option.



3. **Measurements**: ēKoView stores sensor values by types. As new sensor data is sent from ēKo nodes their types will be displayed in this menu selection. Users can view available sensors by clicking on the ► button next to the sensor type to expand the selection. You may also click on icon to expan all selections. ēKoView allows users to plot any sensor value of the same type on a chart axis. For example after selecting **Ambient Temperature** check-box, ēKoView grays out other types of sensors that do not record temperatures. Users can check any of the non-grayed out sensor types to be charted.



4. **Sensors**: After selecting a Measurement type, ēKoView removes all ēKo nodes from the sensor list that do not contain a sensor with the selected measurement type. Users can now select the displayed ēKo nodes they want to plot on the right.



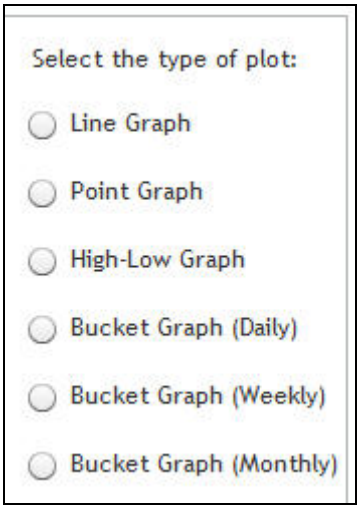
The chart wizard has several icons to simplify the selection of the sensors associated with different nodes.

Chart Wizard Icon	Description
	Expand All icon
	Collapse All icon
	Select All icon
	Unselect All icon

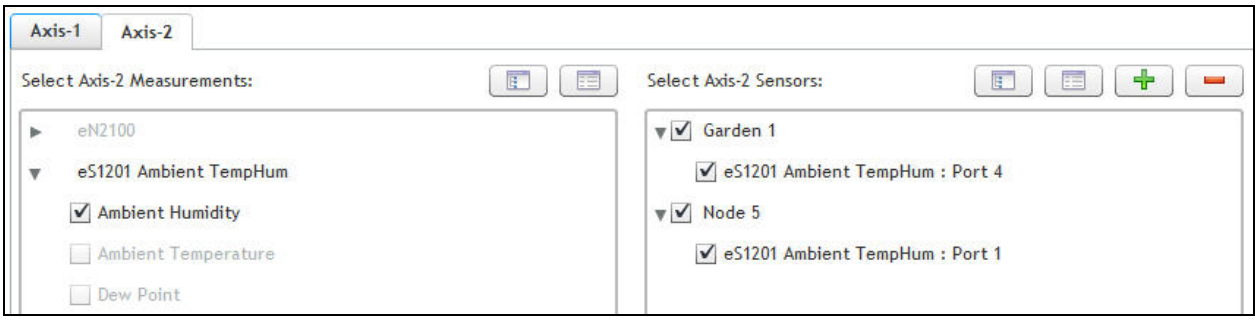
If an ēKo node contains several sensors that have the same measurement type users may only wish to chart one of the sensors, using the **Expand All** button. ēKoView will show all attached sensors. Then you can uncheck the sensors that you don't want to plot.

5. **Plot Type**: Trend chart traces can be plotted in the following modes

- Line graph : connects data points by lines
- Point graph : single data points
- High-low graph: display the maximum and minimum of data for aggregated data (i.e. daily, weekly, monthly, yearly).
- Bucket Graph: display the cumulative or average data in the form of bars (Daily, Weekly, Monthly)



6. **Axis-2 chart**: This is the similar to Axis-1 but plots data on a secondary axis.



NOTE: When using dual axis graphs, plot the first axis using line mode and the second using point mode.

7. Click on **OK** button. After completing the wizard ēKoView will retrieve the specified data and chart it.

6.3.2 Viewing chart data

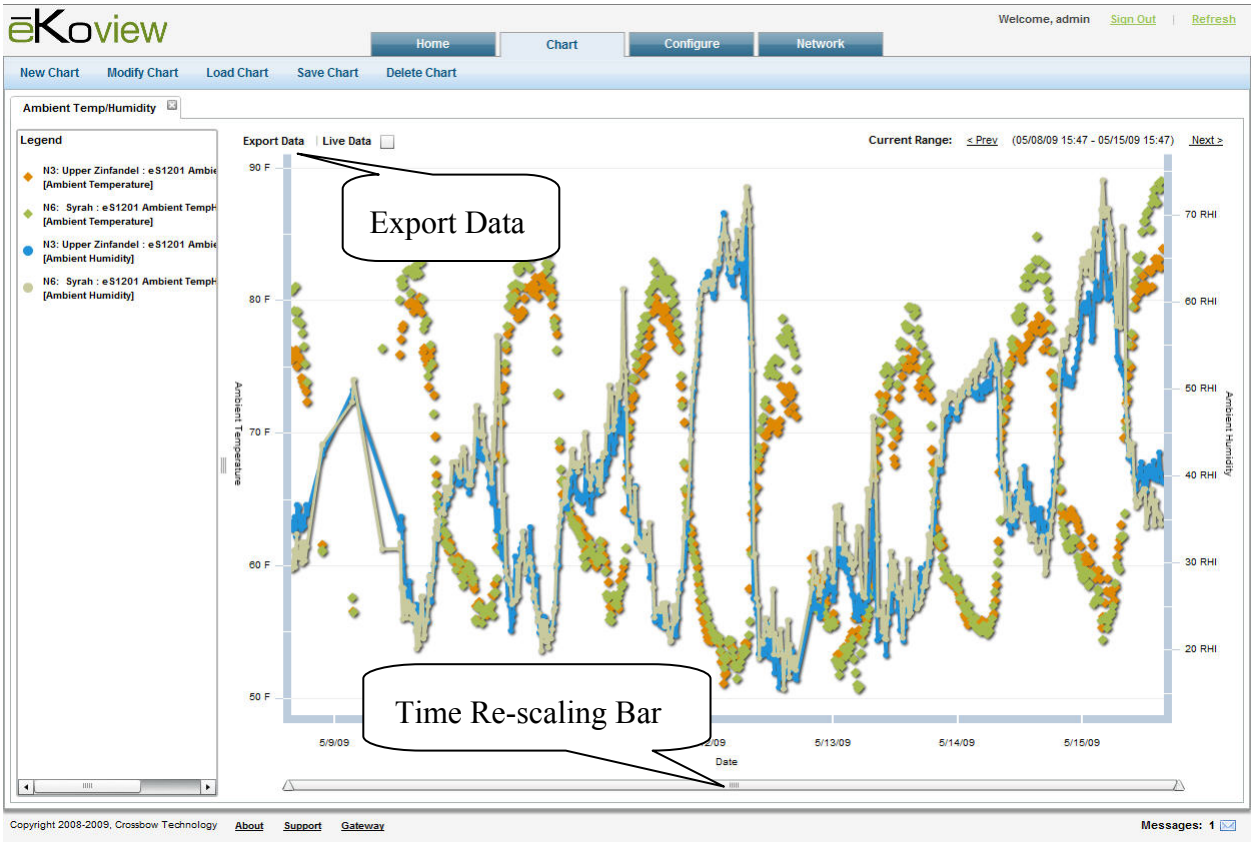
To view a specific value and time on the chart, place the mouse over the point and a pop up with the exact value and time will appear. The slider bar at the bottom of the chart page allows users to shift re-scale the time range on x-axis. To shift the time range, left-click the mouse on either ends of the slider bar and slide the mouse.

Each chart is displayed as a named tab in the Charting window. Users can switch between charts by clicking on the named tab for the chart to be displayed. Unused charts can be closed by clicking on the ☒ in the chart tab.

When viewing a detailed data set, users can choose to select the **Live Data** check-box. This will continually update the chart with any new data that arrives from the network. This button is only available on detailed data, and is not available when viewing aggregate data sets.

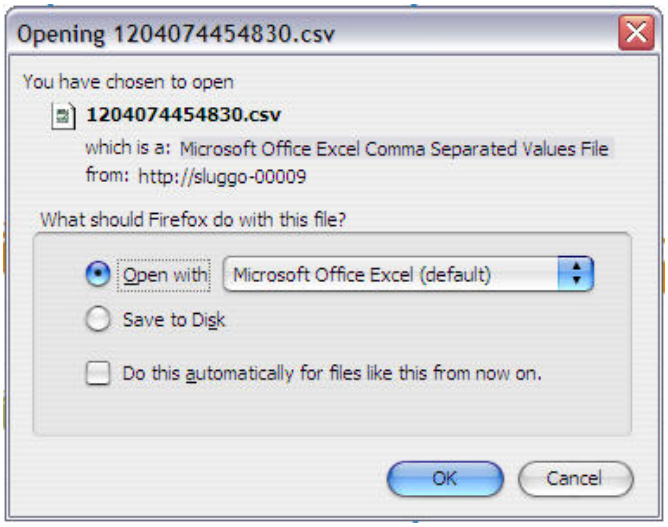
When viewing a chart, users can click the Refresh button on the top right of the window to refresh the chart with current data. When viewing a chart with a pre-defined Date Range, this will readjust the chart window with data from the end date of the date range starting from the current time.

The pre-defined date ranges such as Last Hour, Last Day and Last Week are relative date ranges. This means that when the chart is loaded it will select data using the time of loading as the end time and will select the start based on the relative date range. When a custom date range is reloaded, the given start and end date will always be used.



6.3.3 Exporting data

From the chart tab, users can export the displayed data to a CSV file. When viewing a chart, you can export the chart data by clicking on the "**Export Data**" link at the top left side of the page. A Windows dialog box will appear to open or save the file. You can later view or edit this file using MS Excel.



NOTE: If you have the pop-up blocker enabled on your browser, you may have to allow it to open pop-ups for the ēKoView page.

Large Datasets

ēKoView attempts to display large datasets which can be accumulated over long time ranges in a meaningful manner to the user. To do this, ēKoView uses aggregated data for charts that span long time ranges. The aggregate data is displayed as an average over a time range with a minimum and maximum value. Users can view the detailed data of an aggregate by specifying a shorter date range which encompasses that data point.

- Charting date ranges less than 14 days displays detailed data for every point.
- Charting date ranges between 14 days and 94 days are displayed as hourly aggregates of the data.
- Charting date ranges between 94 days and 300 days are displayed as 6 hour aggregates of the data.
- Charting date ranges between 300 days and 900 days are displayed as daily aggregates of the data.
- Charting date ranges over 900 days and 9000 days are displayed as 10-day aggregates of the data.
- Charting date range greater than 9000 days is displayed as 30-day aggregates of the data.

Plot Type

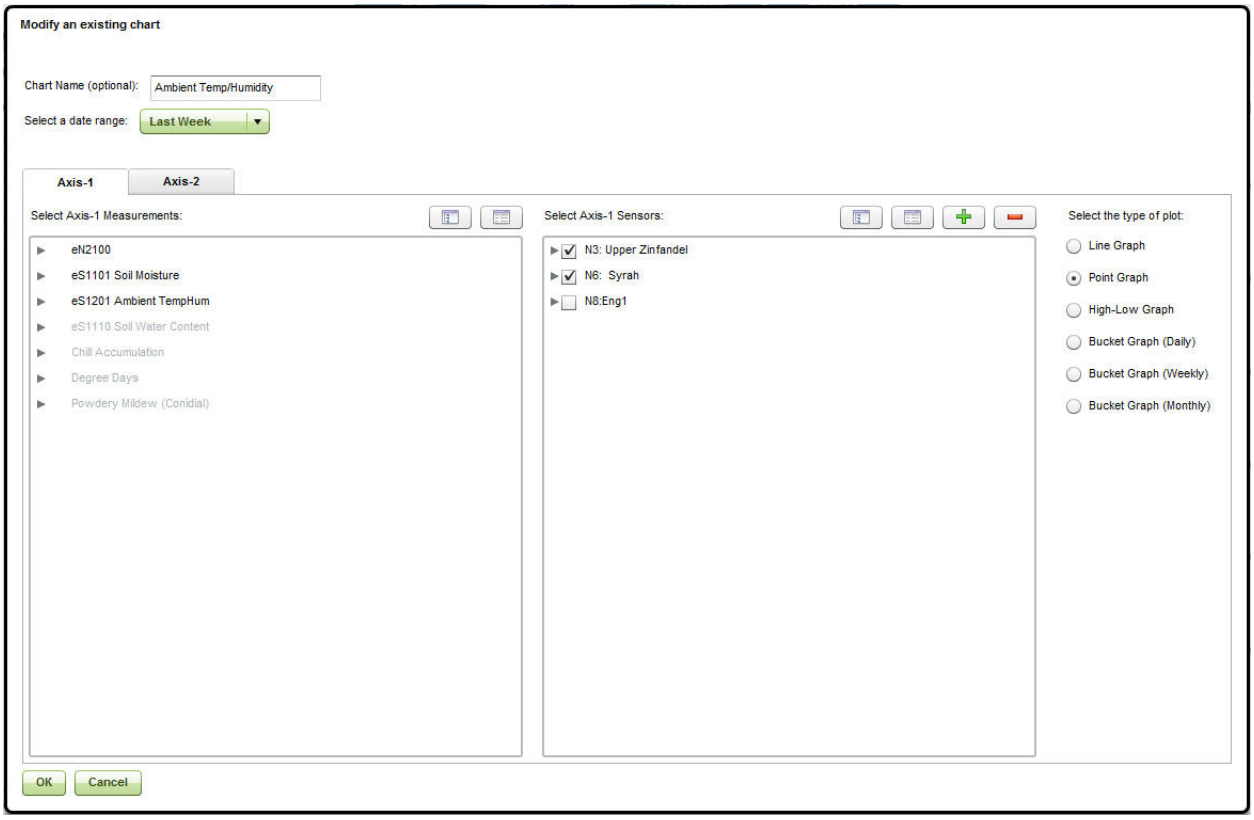
When displaying data, the user can choose one of six plot types: **Line**, **Point**, **High Low**, or **Bucket Graph**. Line plots connect a line between the individual data points, attempting to interpolate the trend being displayed. Point plots display each data value as a point with not connections. The High-Low plots display each data value as a bar ranging between its maximum and minimum value. Finally, Bucket graph displays accumulated change over specified bucket size (eg. daily, weekly monthly) for certain agricultural calculations (eg. Chill hours, Degree days, Powdery Mildew) and average value over specified bucket size for the sensor values.

The data values plotted for a particular chart depends on the whether a detailed or aggregate data point is displayed. When displaying detailed data the Line and Point plots display the actual data value. Since detailed data does not have a maximum and minimum value (like aggregate data), the High-Low plot displays as a Point plot for detailed data values.

When displaying aggregate data the Line and Point plots display the average value of the aggregate point over that time. The minimum and maximum value for the aggregate is displayed when the mouse is held over a point. The High-Low plot displays a bar representing the maximum and minimum value over that time range. The average value is displayed when the mouse is held over the bar.

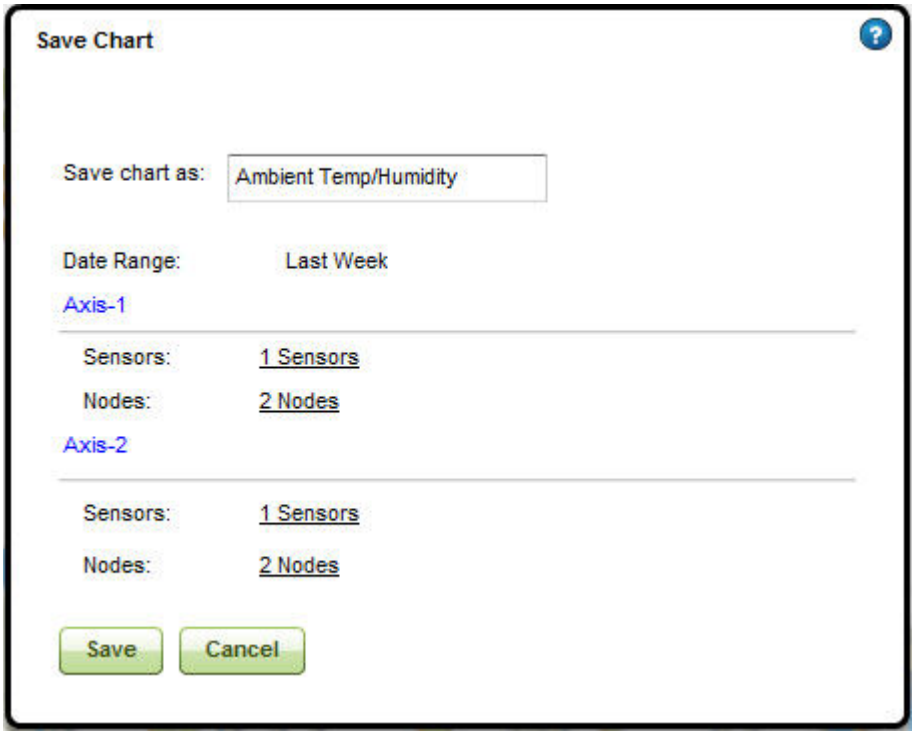
6.3.4 Modifying a chart

Once a chart has been created, user can modify the current chart. When the user clicks on the **Modify Chart** button, Modify an Existing Chart dialog is displayed to the user. User can change the desired chart parameters and click on **OK**.



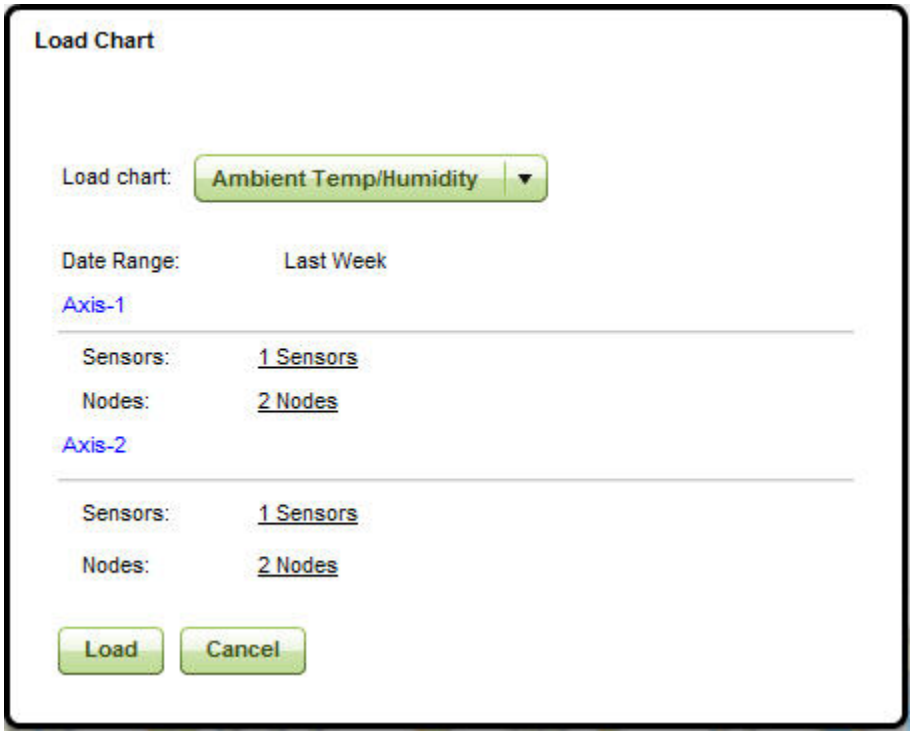
6.3.5 Saving a chart

Once a chart is created a user can save a given chart to be reloaded later. When the user clicks on the **Save Chart** button a Save Chart dialog is displayed to the user. To save a chart the user must select a unique name for the chart. This name will be used later to recall the given chart so it is important that the user uses a descriptive name. A summary of the charts parameters are displayed below the name.



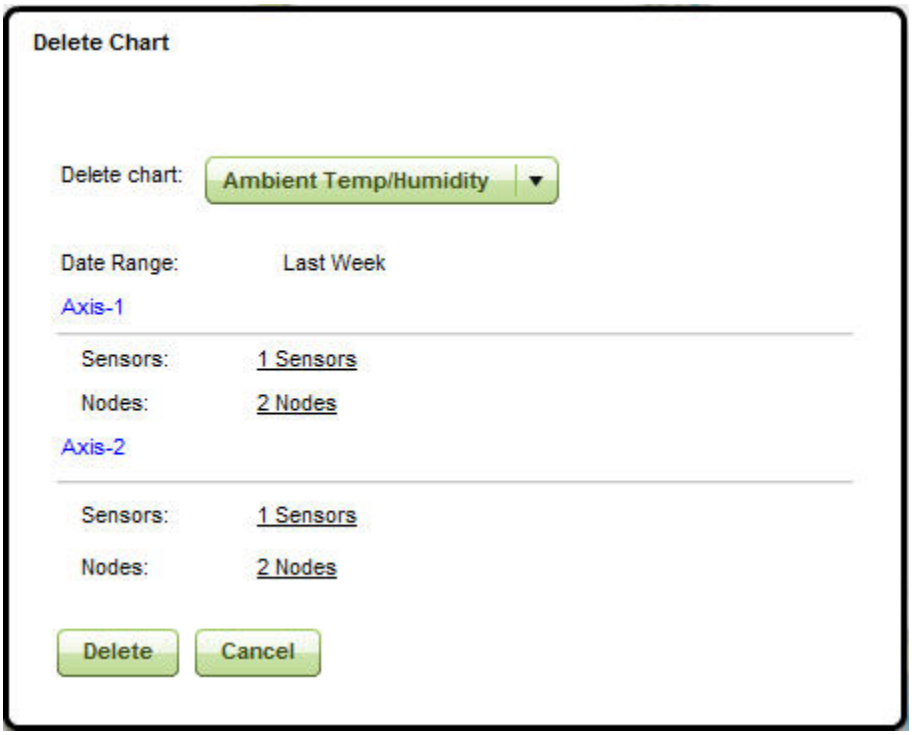
6.3.6 Loading a chart

Once a chart is saved a user can load a given chart at a later date. When clicked on the **Load Chart** button a Load Chart dialog is displayed to the user. The list of saved charts is displayed in the drop down chooser. After selecting a saved chart name, the parameters of that chart as summarized below the chart.

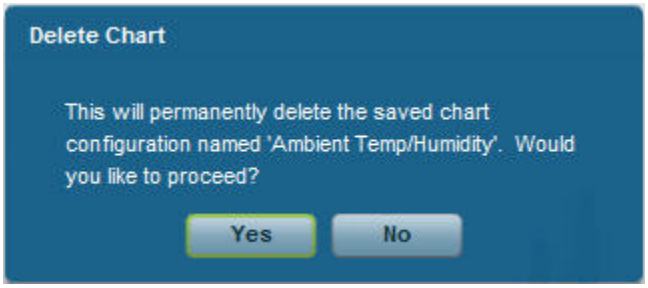


6.3.7 Deleting a saved chart

Once a chart is saved a user can delete a given chart from ēKoView. When the user clicks on the **Delete Chart** button a Delete Chart dialog is displayed to the user. The list of saved charts is displayed in the drop down chooser. After selecting a saved chart name, the parameters of that chart as summarized below the chart.



In the "Delete Chart" confirmation dialog, click on "**Yes**". Once a chart is deleted it is no longer available in the load chart wizard.



The Delete Chart option is used to delete saved charts. Charts which were created with the **New Chart** and are not saved can be removed by clicking the ⊠ in the chart tab.

◀ **NOTE:** You will need admin privileges to save or delete a chart. If you are not logged in as "admin", these buttons will be disabled for you.

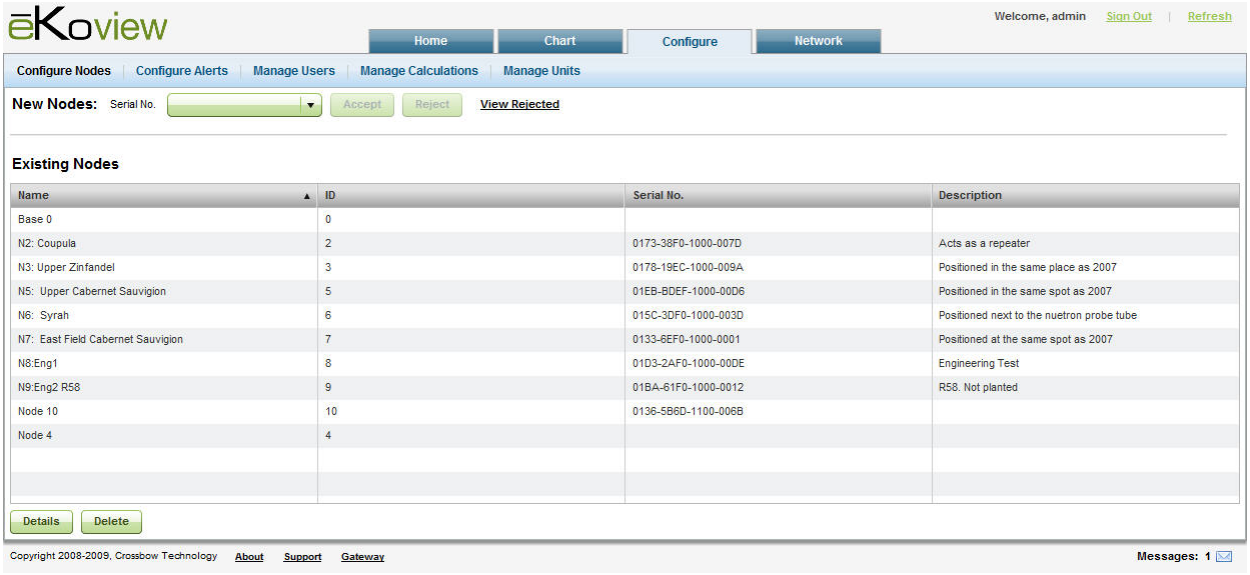
6.4 Configure Tab

The Configuration tab provides a means for commissioning the nodes and configuring node details (such as Node name, description etc). It also provides a way to configure alerts and manage users.

NOTE: You will need admin privileges to access this tab and its pages. If you are not logged in as "admin", the tab will be disabled for you.

6.4.1 Configure Nodes Page

This page provides ability to the user to accept or reject the new nodes trying to join the network. This page also allows users to configure existing nodes that are accepted into the network. The users can specify or change name and description of the node and attached sensors. You can access this page by clicking on "**Configure Nodes**" button in the Configure tab. The new nodes that are trying to join will appear at the top in the "Serial No." drop-down. These nodes need to be accepted before you can configure them (refer to Chapter 4 for node commissioning). The accepted nodes will appear in the "Configure existing nodes" list.



Node Details

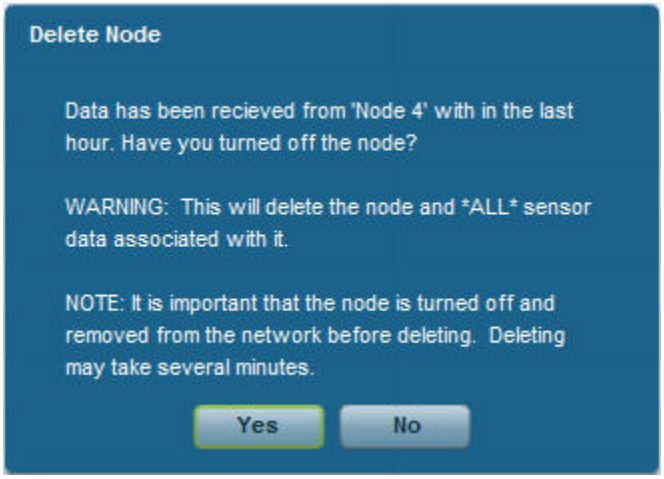
ēKoView allows users to rename both the node and the sensor. Select and highlight the node you wish to rename and click on the "**Details**" button at the bottom of the page. It will bring up the "Node Details" dialog window. Edit the name and description as you wish and then click on the **Save** button. Refer to previous section 5.4.3 for details.

Delete Node

ēKoView allows users to remove a node that is no longer part of the network. Select and highlight the node you wish to remove and click on the "**Delete**" button at the bottom of the page. A conformation dialog will appear if the data has been received from the node within the last hour. Similarly if the alerts are associated with a specified node, you can not delete it until you clear these alerts. Click on **Yes** to confirm the operation.

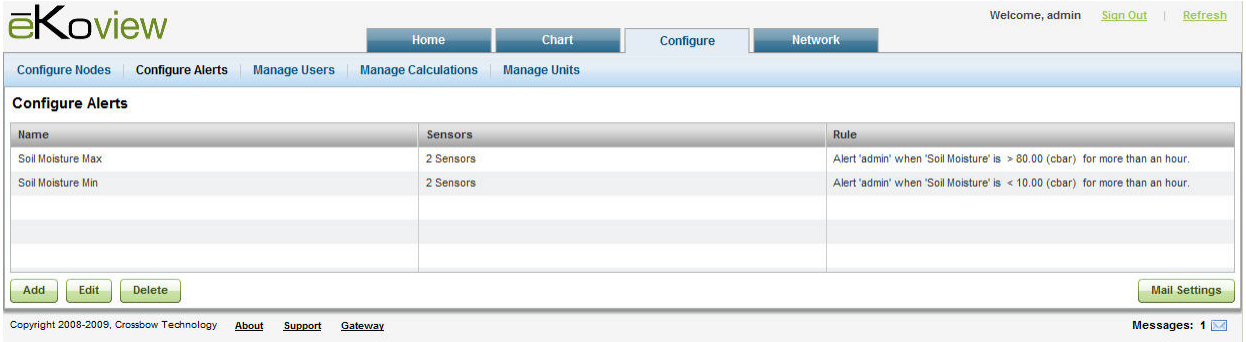
⚠ WARNING

It is important that the node is turned off and removed from the network before deleting. Deleting a node and its data may take several minutes.



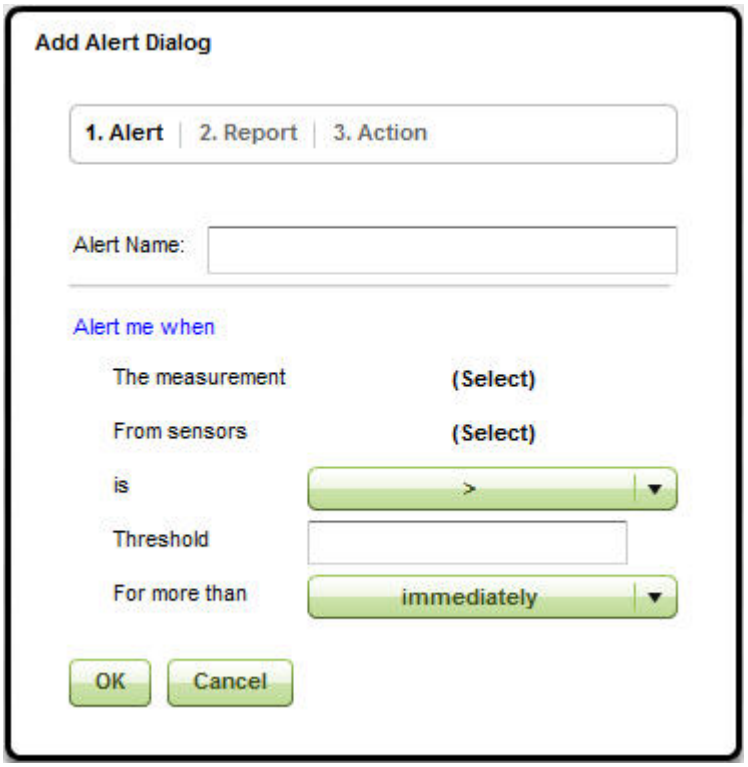
6.4.2 Configure Alerts Page

The ēKoView alert manager allows users to define alert conditions based on any sensor value from any sensor node. An alert is a user programmable event that gets triggered when sensor data goes outside pre-defined threshold. The Configure Alerts page can be accessed from **Configure Alerts** link in the Configure tab.



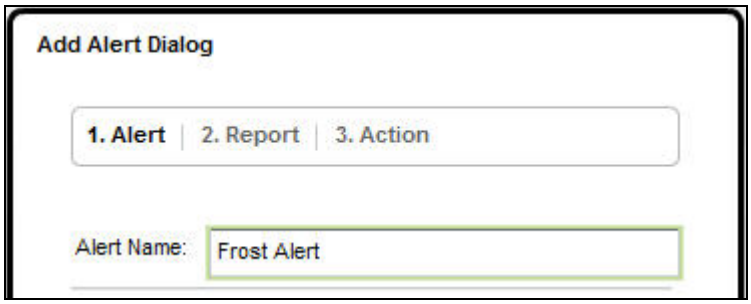
Add a new alert:

To add a new alert, click on the "**Add**" button at the bottom of the page. This will open up Add Alert dialog window as shown below.

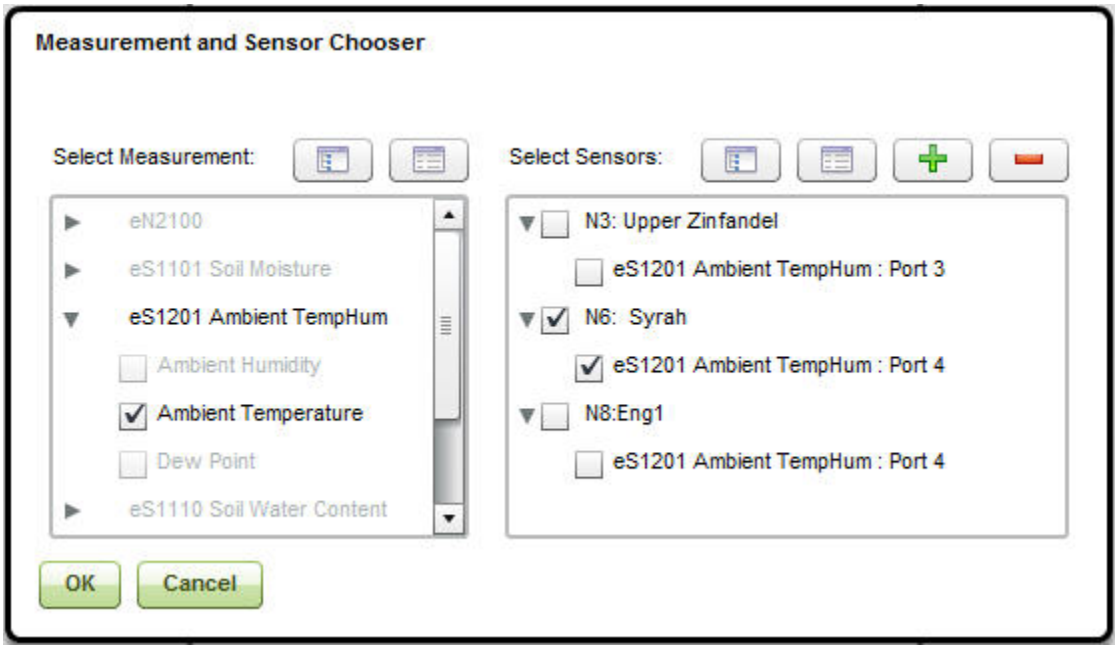


You will need to specify:

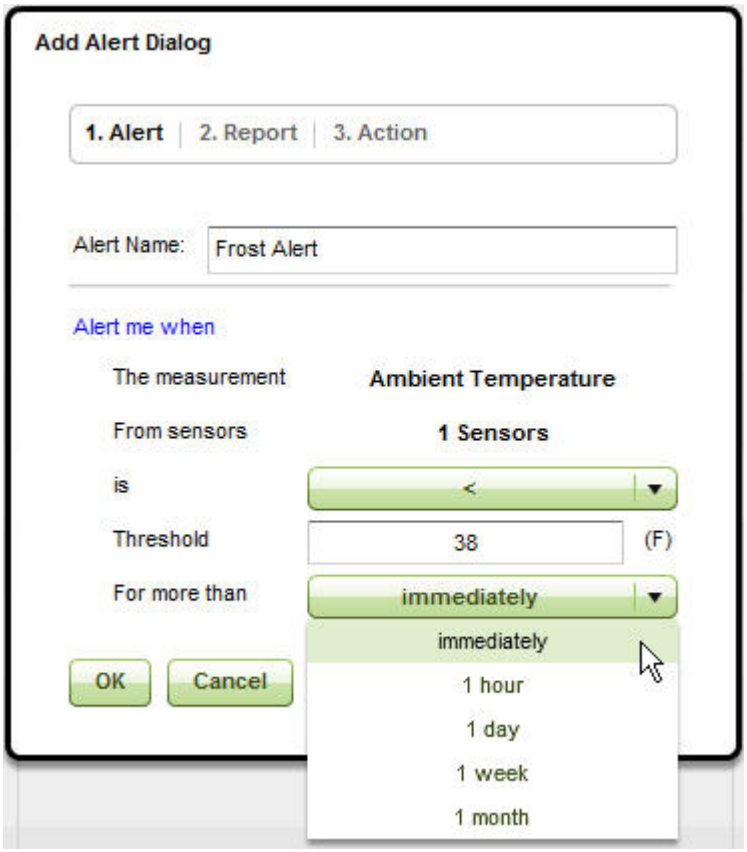
1. **Alert Section**
   - **Name** –Allows to type in a user defined name for the alert.



   - **The Measurement name** – clicking on **Select** button next to "The measurement" will bring up a Measurement and Sensor chooser dialog window. Select the measurement name that you want to trigger an alert.

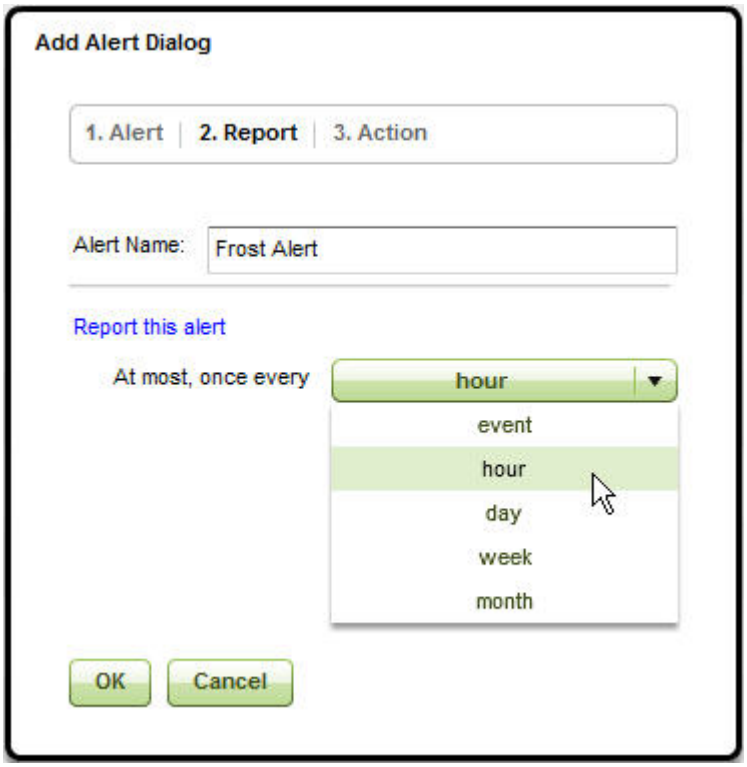


- **Sensor Name** – After selecting a Measurement type, ēKoView removes all ēKo nodes from the sensor list that do not contain a sensor with the selected measurement type. Users can now select the displayed ēKo nodes they want to trigger an alert.
- **Alert Condition** – the comparison operation to decide when an alert should be triggered. From **Alert Condition** drop-down list, specify an appropriate condition to trigger the Alert, viz. "**>**", "**>=**", "**<**" or "**<=**".
- **Alert Threshold** – the value to compare the alert condition against. For **Threshold** field, type in numerical value in the text box, the unit should automatically appear in front of the text box.
- **Alert Duration** –set the duration of time the measurement must be across the threshold before the alert is triggered. From the "**For more than**" drop down list, specify the duration. You may choose from "**Immediately**", "**1 hour**", "**1 day**", "**1 week**" or "**1 month**".



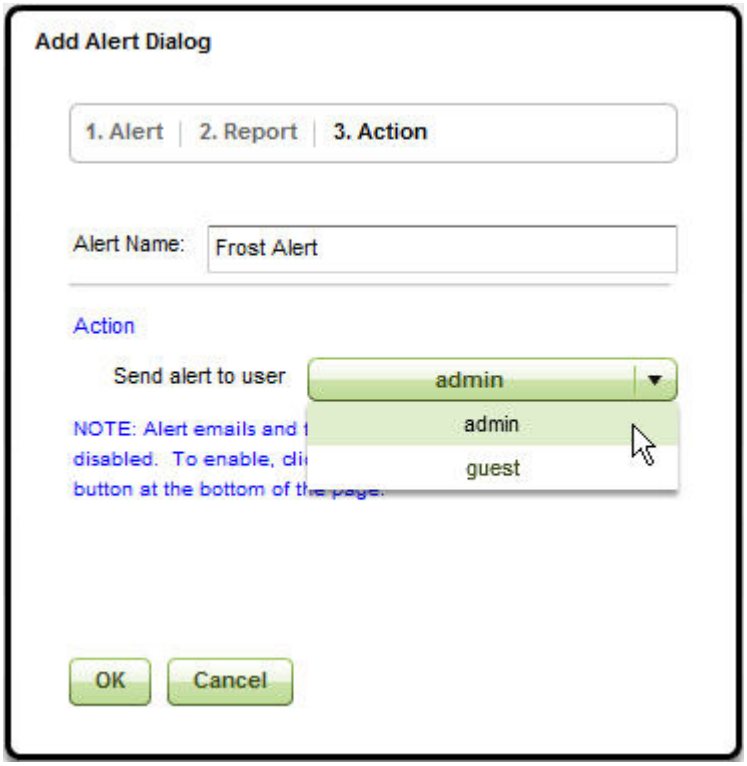
2. **Reporting Section** – specify the maximum number of alerts that can be reported within a time range, no matter how many times the alert has occurred.

   From the "**Remind me every**" drop-down list, specify the interval. You may choose from "**event**", "**hour**", "**day**", "**week**" or "**month**".



3. **Action Section** – specify the operation to perform in response to a triggered alert.

   From the "**Send alert to user**" drop-down list, select the user name you would assign this alert to. The user name list will be automatically populated by ēKoView based on the authorized users list.



When done, click on **OK** button. This new Alert should now appear in the "Configure Alerts" list.

When an alert condition is met, e-mail notification will be sent out to the e-mail address associated with that user (refer to section 6.4.3 for managing users). A sample alert notification e-mail is provided below.

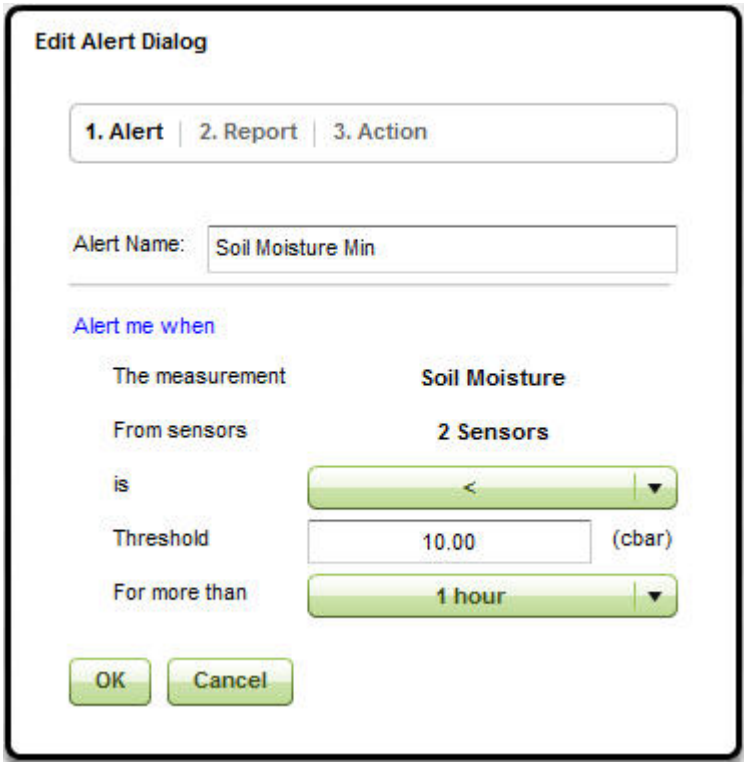
```
Subject: eKoView Alert Message: An alert has occurred on 'Node 203'

Network:     eko-00002
Alert Name:  Battery Voltage < 4V
Occurred:    2008-02-27 13:43:31
Sensor:      'Node 203'
Measurement: 'Battery Volts'

Battery Volts reading 3.84 is < than alert threshold 4.00
```

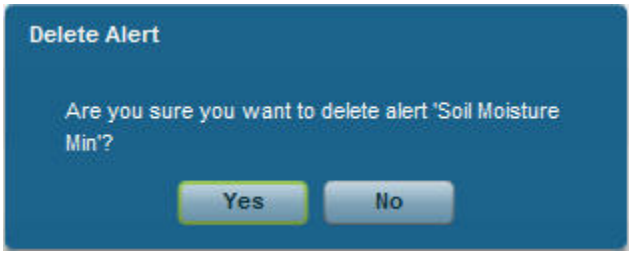
Edit an existing alert:

To edit an existing alert, select and highlight the alert you wish to edit and then click the "**Edit**" button at the bottom of the page. This will bring up the "Edit Alert Dialog" window and you can edit the parameters that you want to change. When done, click on the "**OK**" button.



Delete an alert:

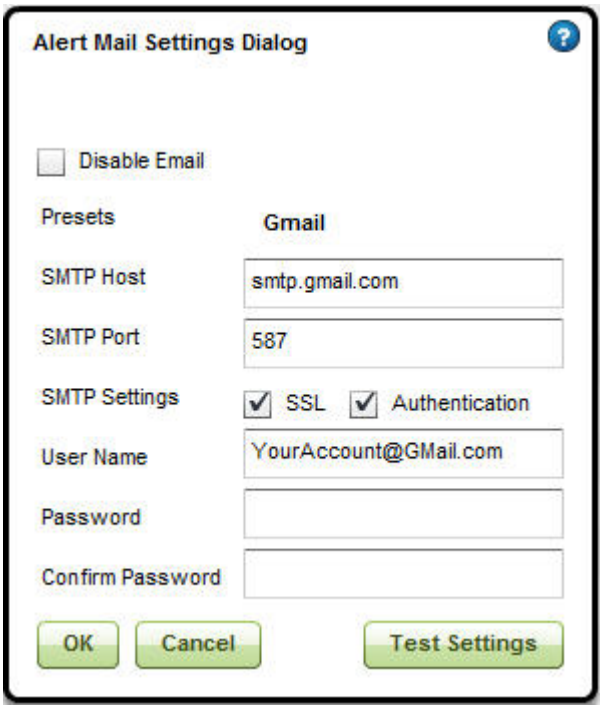
To delete an alert, select and highlight the alert that you wish to delete and then click the "**Delete**" button at the bottom of the page. In the "Delete Alert" confirmation dialog window, click on "**Yes**". The alert will now disappear from the alerts list.



Alert Mail Settings:

For the Alert manager to send Email, the users should first configure their SMTP mail settings. These mail settings pertain to that of the alert sender. This can be accomplished as follows:

1. Click from **Mail Settings...** button at the bottom right side of the Mail Configure page. This will bring up Alert Mail Settings Dialog window.



NOTE: The dialog window provides SMTP presets for Gmail as an exmple. If you are using one of the other mail service provides (eg. Comcast, SBC, AT&T etc), you should consult the service provider for these SMTP settings.

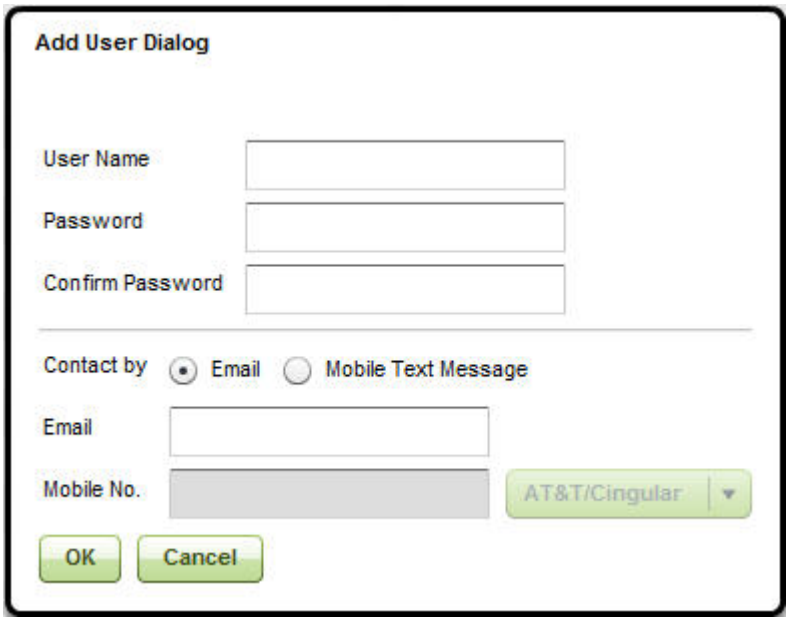
2. Uncheck "**Disable Email**" check-box.
3. Enter the **SMTP Host** name and **SMTP Port** number of the mail server
4. Specify the **SMTP Settings** for the mail server
5. Specify the **User Name** and **Password** of sender's mail account
6. Click on **OK**.
7. You can verify the mail settings by clicking on "**Test Settings**" button and if everything is correct, you should receive a test e-mail sent to the e-mail account associated with admin.

6.4.3 Manage Users Page

This page allows the administrator to add, edit or delete the users that can log into the ēKoView web portal. You can access this page by clicking on **Manage Users** link in the Configure tab.

Add a new user:

To add a new user, click on the **Add** button at the bottom of the page and a "Add user dialog" dialog window will appear.

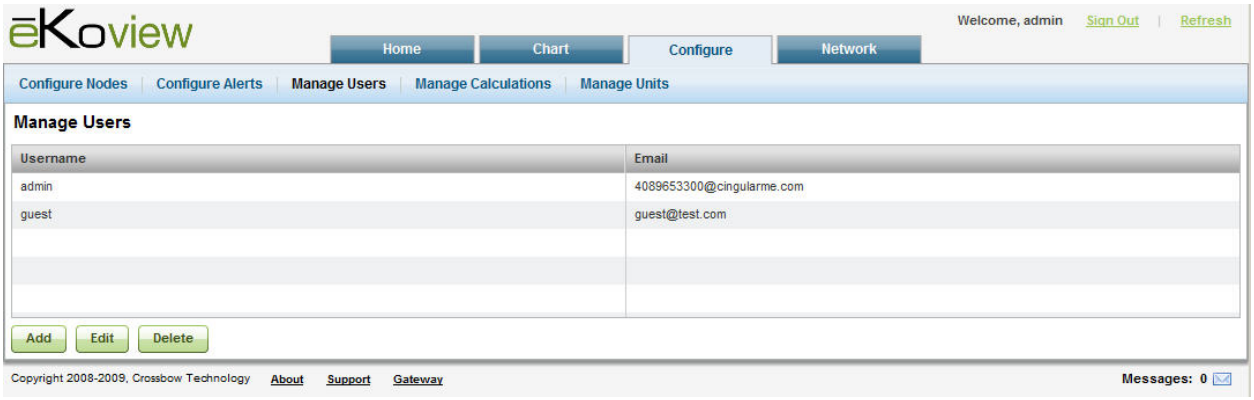


You will need to specify:

1. **User Name –** login name for the user you want to provide ēKoView guest access
2. **Password -** password to login to ēKoView (can only be alphanumeric)
3. **Contact by –** radio button for alert notification
4. **Email** – if you choose to send alerts by e-mail, specify the e-mail address for the recipient
5. **Mobile No.** – if you choose to send alerts by Mobile Text message, select the cellular provider and specify the number (10 digits without any dashes or spaces)

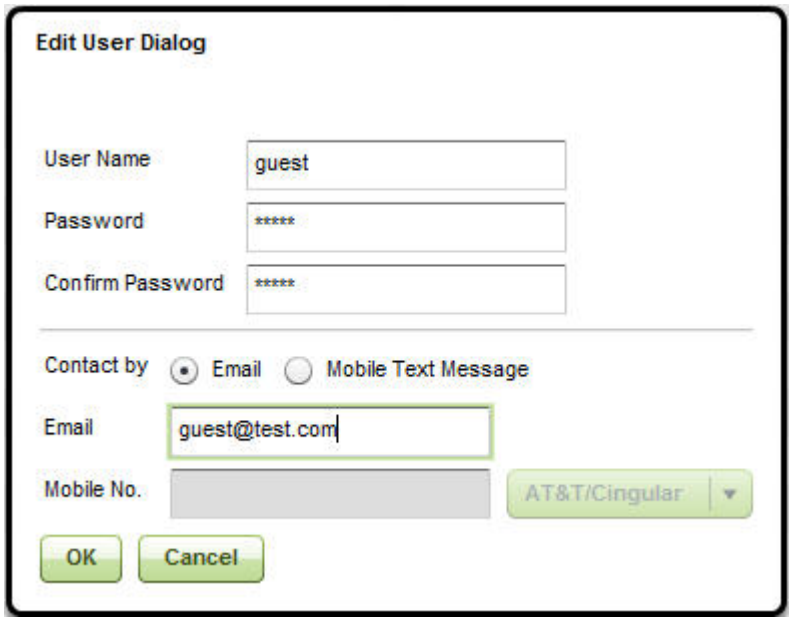
NOTE: The dialog window provides SMS presets for commonly used mobile services such as AT&T/Cingular, Sprint, T-Mobile and Verizon. If you are using one of the other cellular service provides, you should consult your service provider for these SMS settings (eg. the webpage http://www.notepage.net/smtp.htm provides these settings for several common cellular providers). Once you know the E-mail address for SMS messages, use contact by E-mail option and then specify this e-mail address.

When done, click on **OK** button. This new User should now appear in the "Manage Users" list.



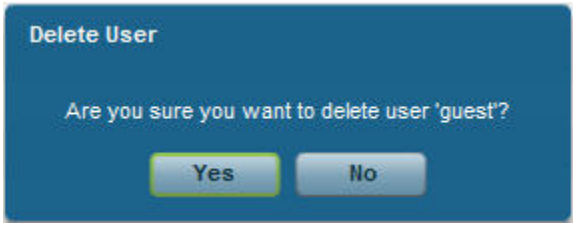
Edit an existing user:

To edit an existing user, highlight the user you wish to edit and click on the "**Edit**" button at the bottom of the page and the "Edit User Dialog" window will appear. You can edit the parameters that you want to change. When done, click on the "**OK**" button.



Delete an existing user:

To delete an existing user, highlight the user you wish to delete and click on "**Delete**" button. In the "Delete User" confirmation dialog, click on "**Yes**". The user will now disappear from the user list and will no longer be able to log into the ēKoView.



6.4.4 Manage Calculations Page

This page allows the administrator to define, edit or delete some key agricultural-related calculations based on certain sensor inputs. These estimates help growers with better insight into the crop health, disease outbreak predictions etc. You can access this page by clicking on **Manage Calculations** link in the Configure tab.

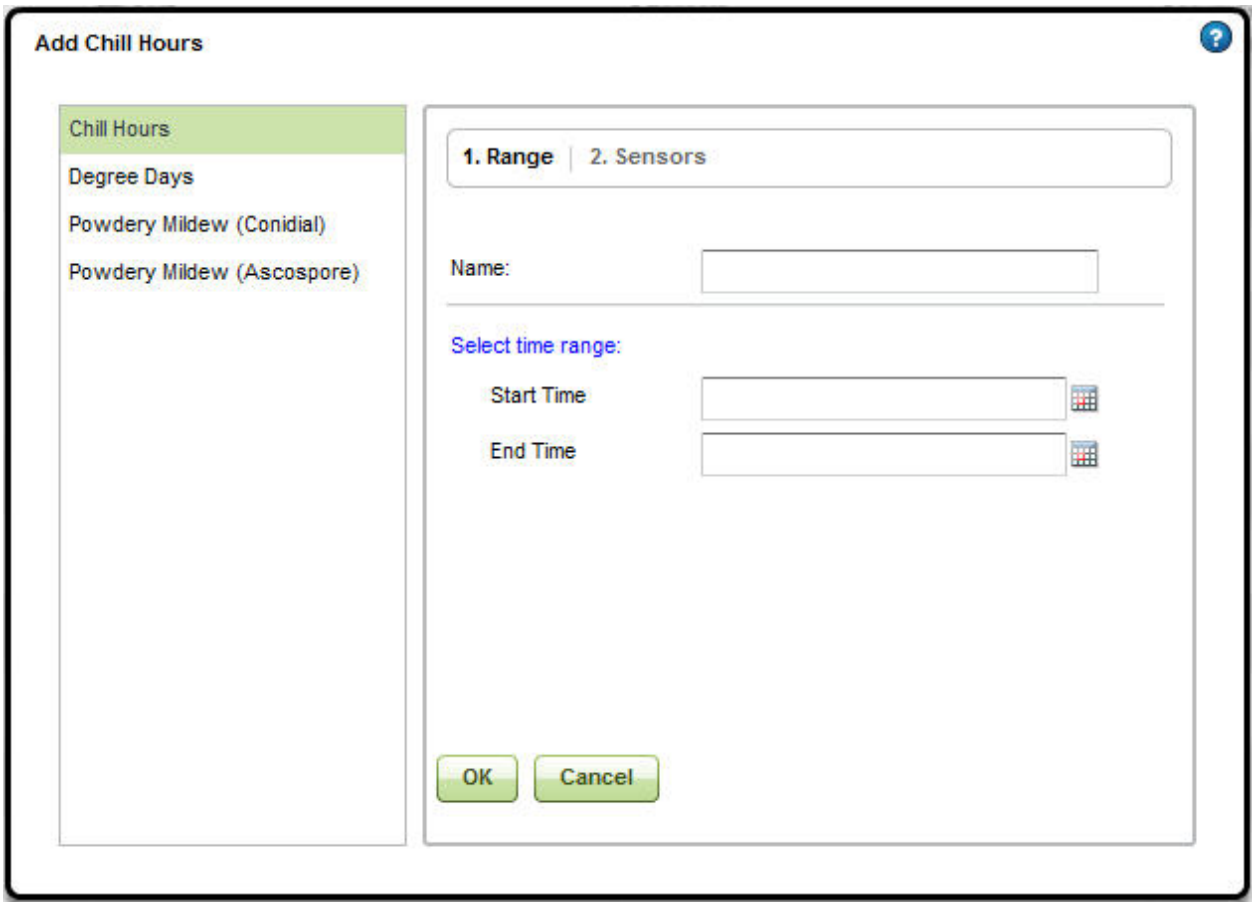
eKoView presently supports the following calculations:

- Chill Hours
- Degree Days (Heat)
- Powdery Mildew (Conidial)
- Powdery Mildew (Ascospore)

After calculations are configured in the 'Manage Calculations Page' users can view the results in other eKoView web pages similar to sensor data. For example the calculation results can be plotted or configured for alarms.

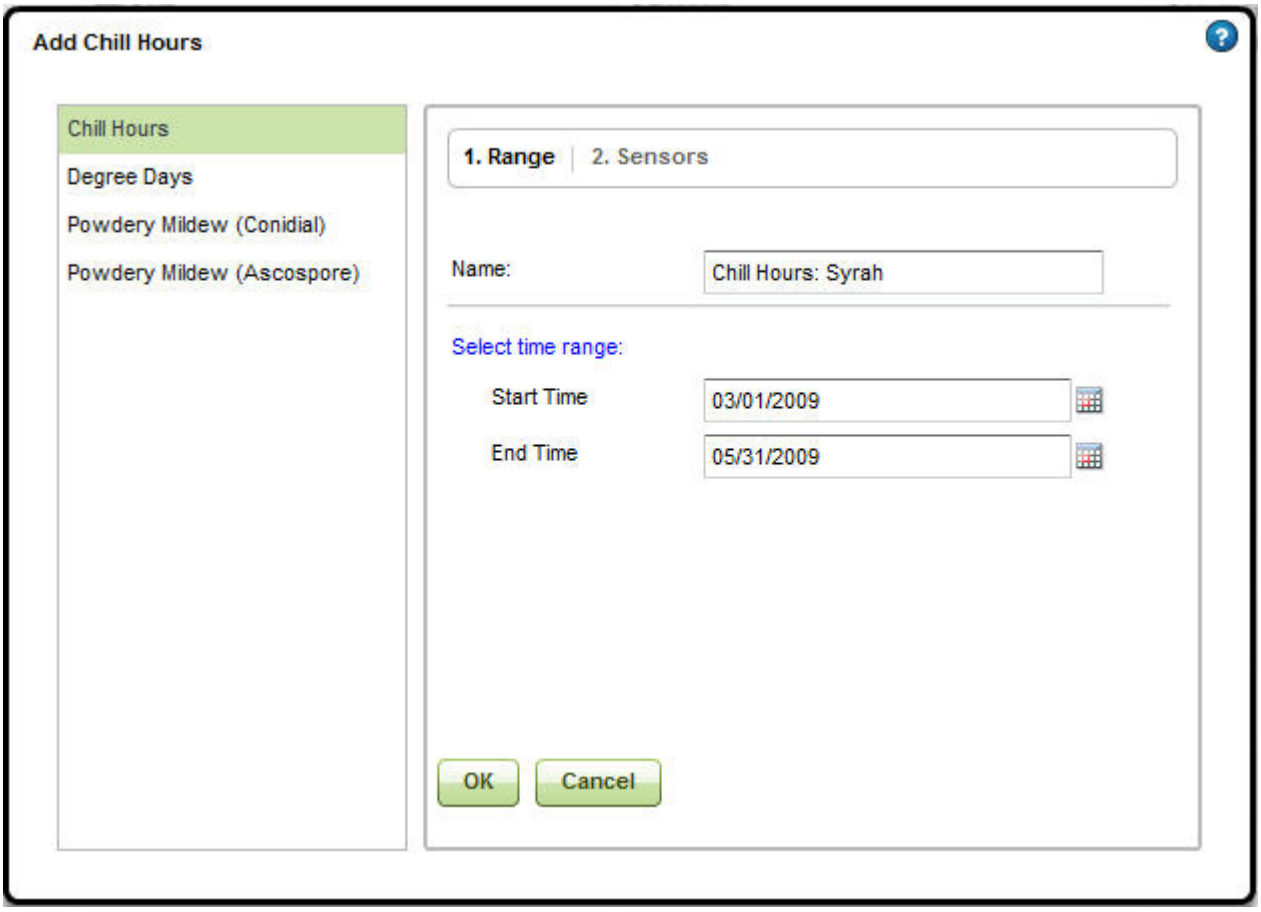
Adding new calculations:

To add a new calculation, click on the **Add** button at the bottom of the page and the "Add calculations" dialog window will appear.



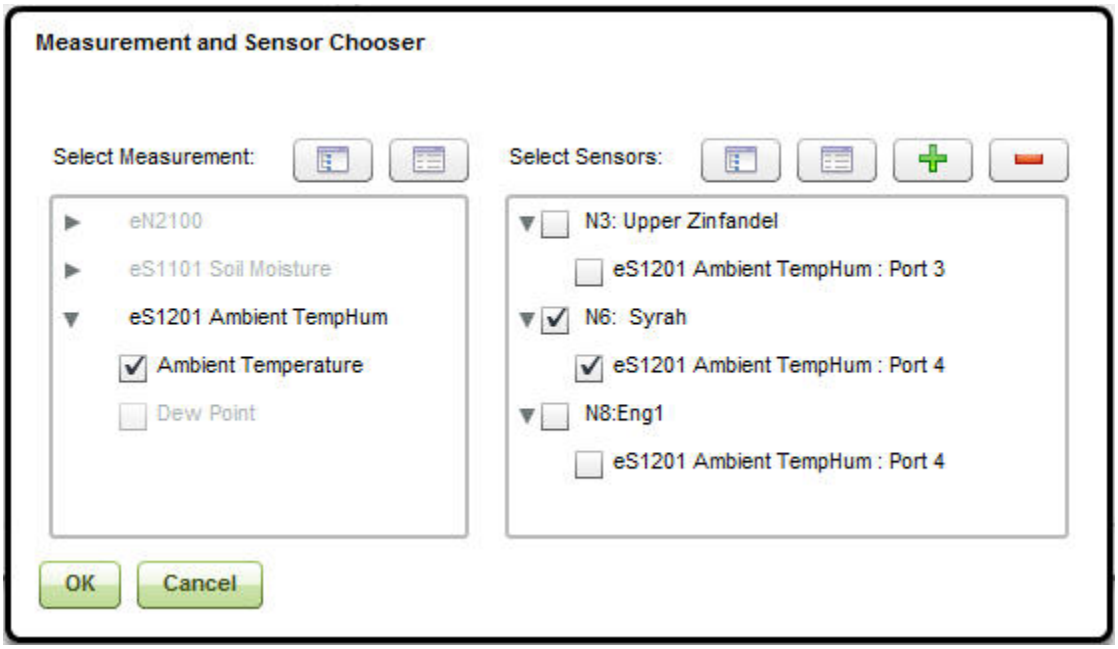
You will need to specify:

1. **Range Section**
   - **Type** – Select the calculation type from the left hand side.
   - **Name** –Type in a user defined name for the calculation.
   - **Time Range** – Specify a **Start Time** for the calculation. Typically start time is before dormancy. Also, specify the End Time which is usually when dormancy ends.

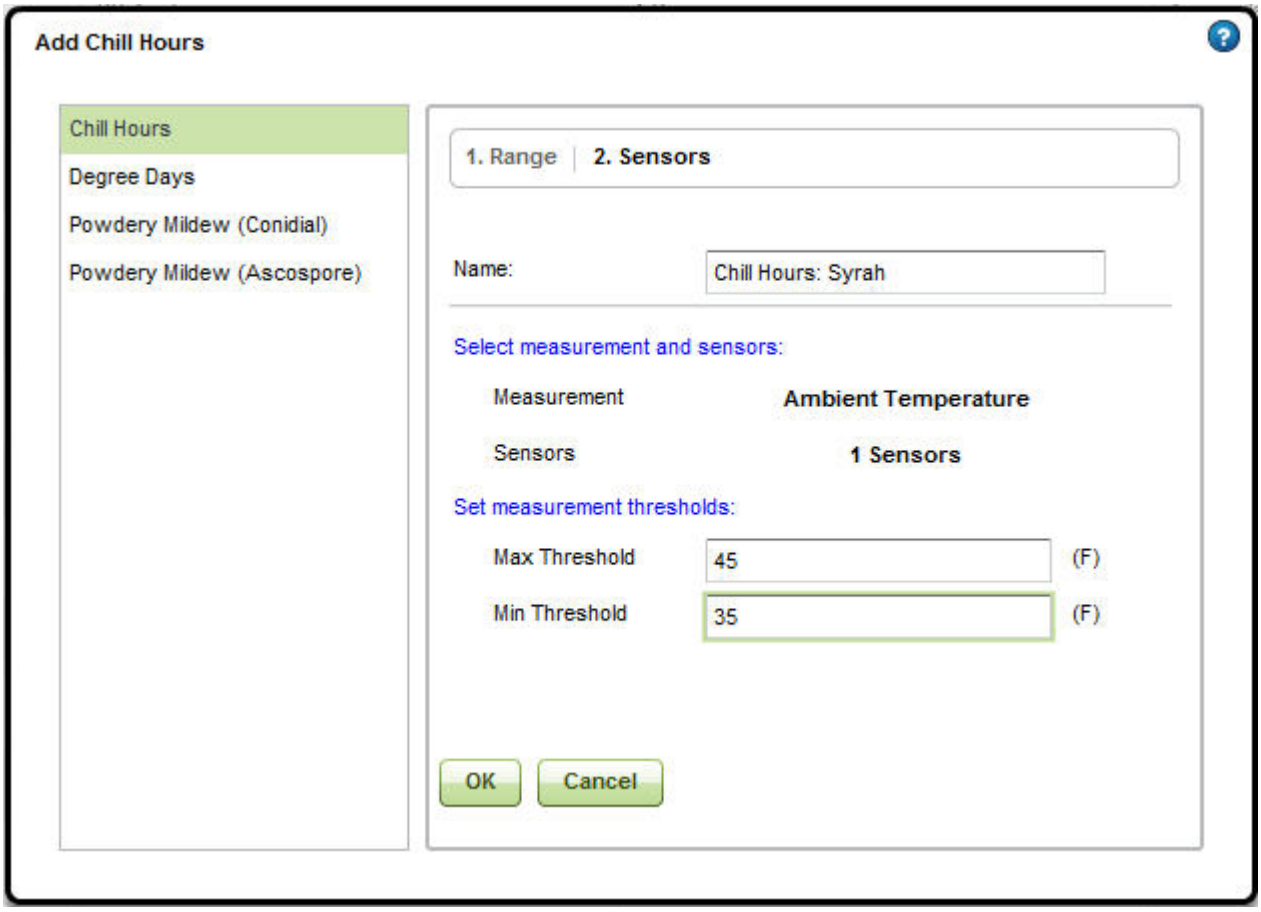


2. **Sensors Section**

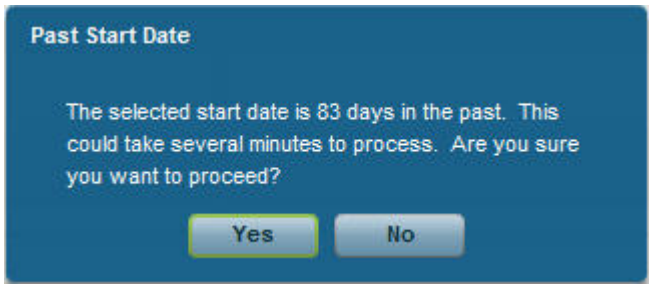
- **Nodes** and **Sensors** – clicking on **Select** button next to "Sensor" or "Measurements" will bring up a Measurement and Sensor chooser dialog window. Select the sensor measurement that you want to use for the calculations. The same calculation name and conditions can be applied to several sensors in the network.



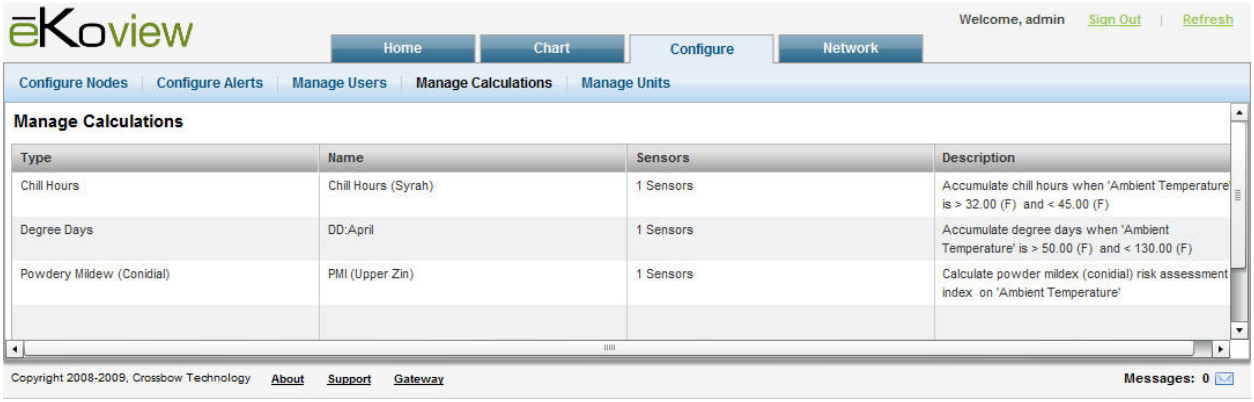
- **Threshold** – lets you set the max and min threshold values for the calculation. The calculations only accumulate for temperatures between the Max Threshold and Min Threshold. Thresholds are usually crop specific.



When done, click on **OK** button. If the Start date chosen is in the past you, it could several minutes to complete calculations and you will receive the message below. Click on "**Yes**" if you want to proceed.

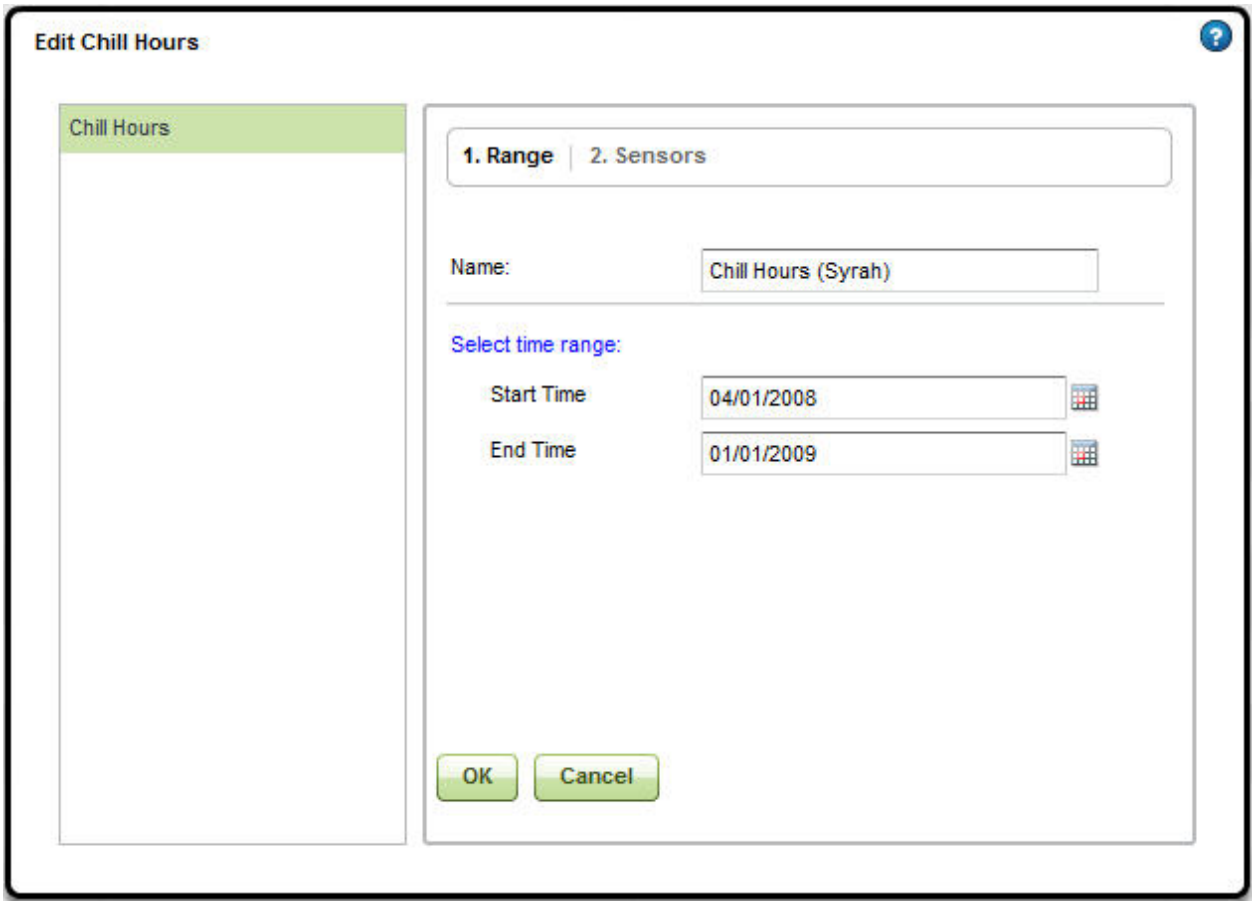


The newly created calculation should now appear in the "Manage Calculations" list. These calculations will now show up as a sensor measurement with each of the associated nodes. They can also be displayed or plotted as any sensor measurements.



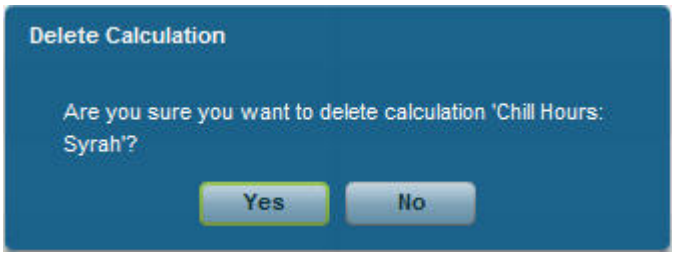
Edit an existing calculation:

To edit an existing calculation, highlight the calculation you wish to edit and click on the "**Edit**" button at the bottom of the page and the "Edit Calculation" dialog window will appear. You can edit the parameters that you want to change. When done, click on the "**OK**" button.



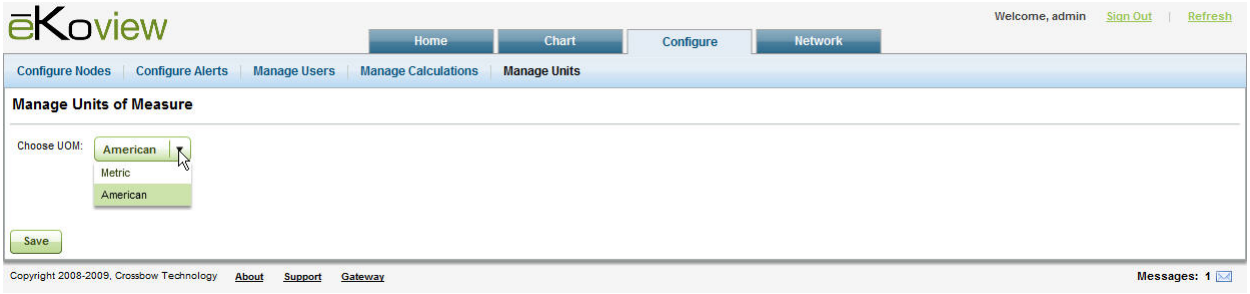
Delete an existing calculation:

To delete an existing calculation, highlight the calculation you wish to delete and click on "**Delete**" button. In the "Delete User" confirmation dialog, click on "**Yes**". This calculation will now be removed from the calculations list and will no longer be available in ēKoView.



6.4.5 Manage Units Page

This page allows the administrator to specify the default units of measure for ēKoView page display. You can access this page by clicking on **Manage Units** link in the Configure tab.



Choose the desired unit of measure from the drop-down box and click on "**Save**" button. This will change the default unit of measure in ēKoView "Sensors" and "Chart" pages.

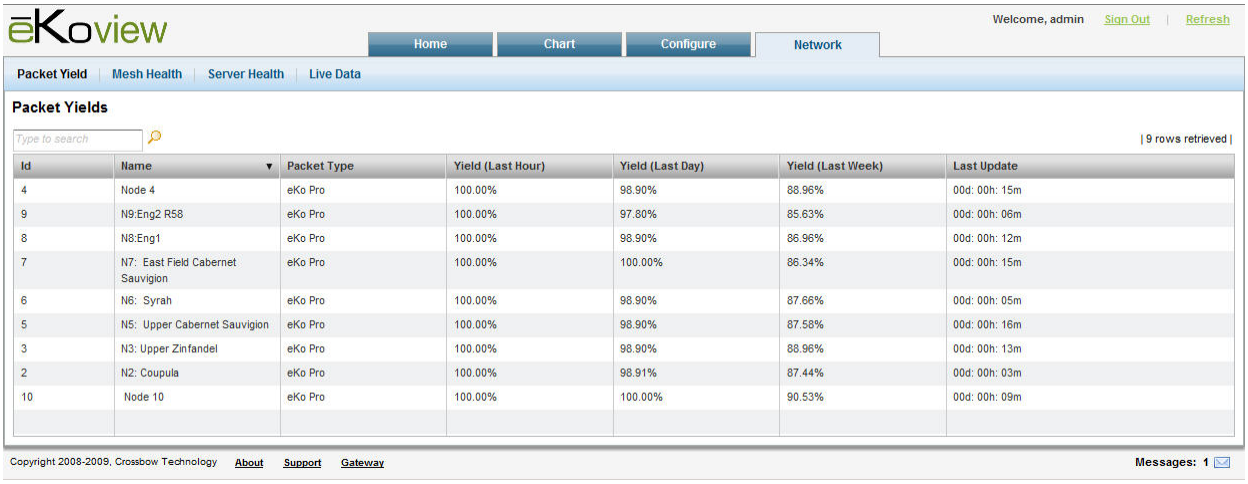
6.5 Network Tab

The Network tab displays network diagnostic information, used to determine network health. The Network tab has four pages:

- **Packet Yield**: This page gives hourly, daily and weekly yields for each type of data packet coming from a node.
- **Mesh Health**: This page displays per node health statistics such battery voltage and number of hops. It also gives neighbor information about a particular node.
- **Server Health**: This page displays the gateway server's uptime and throughput.
- **Live Data**: This page provides a tabular, searchable view of the live data from the sensor nodes as they arrive.

6.5.1 Packet Yield Page

The Packet Yield page displays hourly, daily and weekly display statistics for each type of data packet arriving from a node. Yield is displayed as a percentage over the given time range. In addition, the number of packets received by the server over the number of packets generated by the node is also displayed in parenthesis next to each yield number.



6.5.2 Mesh Health Page

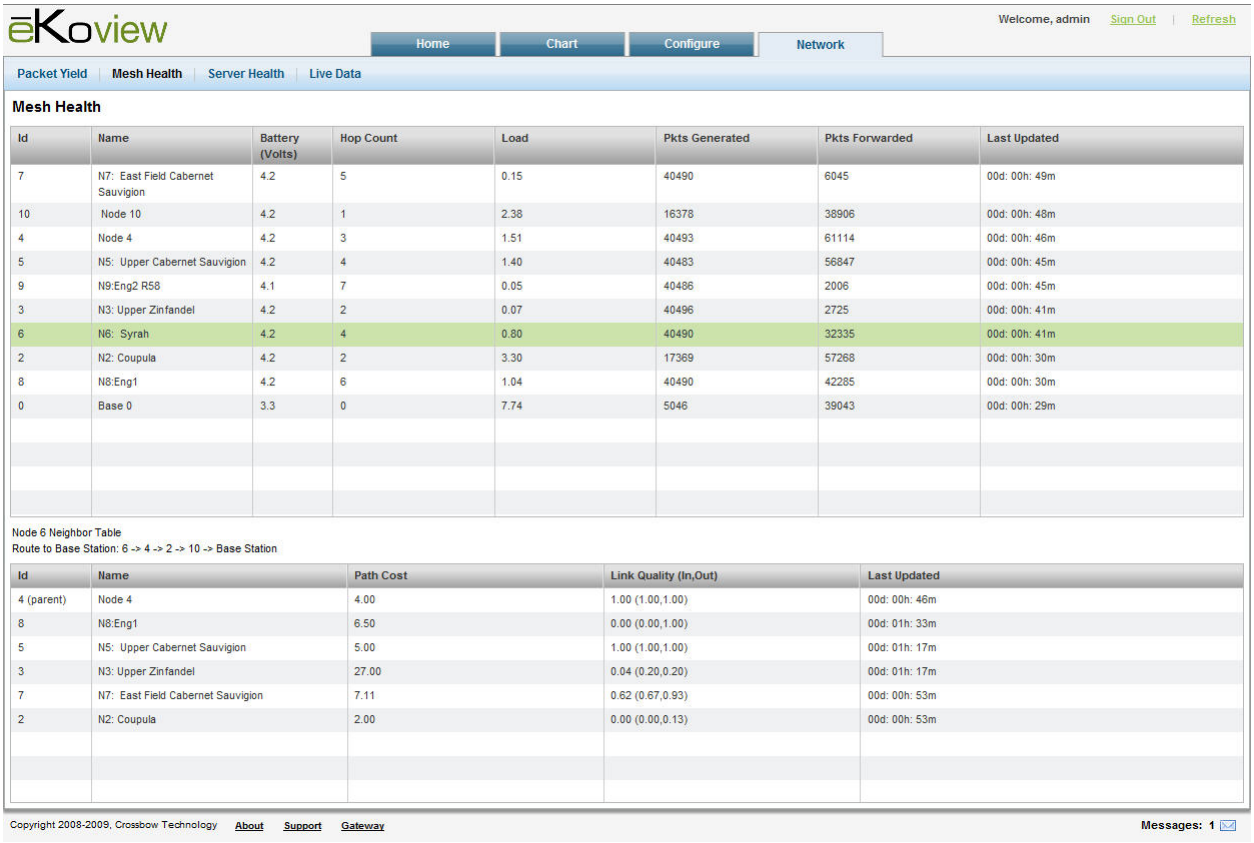
The Mesh Health page displays per node health and neighbor statistics. The data displayed is the following:

- Battery Voltage: This is the current battery voltage of the node.
- Hop Count: This is the number network hops this node is from the base radio gateway.
- Load: This indicates the amount of extra work this node is doing for other nodes in the network. The value is the number of packets forwarded by this node over the number of packets generated by this node. A load of 1 means that it is forwarding as many packets at is generating. High load node could be considered bottle-necks in the network and can run out of batteries quicker than other nodes in the network.
- Packets Generated: This is the number of packet generated by this node.
- Packets Forwarded: This is the number of packet forwarded by this node.
- Last Updated: This is the last time this node has sent an update of its state.

In addition to these health statistics, the page also displays neighbor and route information in the lower neighbor table. To display the neighbor and route information for a particular node click on the row for that node in the node table.

The neighbor table displays the route the node takes back to the base radio gateway above the neighbor table. In addition for each neighbor to the node it displays the following:

- Path Cost: The path cost is a metric which represents the quality of path to the base radio going through that node. A path cost equal to the hop count of the node is considered a perfect path. The larger the path cost the worse the quality of the path.
- Link Quality: This is the quality of the link to the particular neighbor. A quality of 1.0 is perfect and a quality of 0 is bad. The overall link quality is the product of the quality in from that neighbor and the quality out to the particular neighbor.
- Last Updated: This is the last time the node sent information about this neighbor.



Troubleshooting using Network Tab:

If the packet yield of a node is poor or intermittent check the Mesh Health page. This view will show the RF connectivity of a unit to its neighbors. The neighbor table displays all neighbors that the unit can communicate with and the Link Quality is a measure of how good the node can receive messages from the neighbor and how well the neighbor can receive messages from the node (bi-directional quality). A link quality of 1.0 indicates that 100% of messages are received.

Link Quality 0.95, 0.50 means that the node receives 95% of the messages from the neighbor and the neighbor receives 50% of the nodes messages.

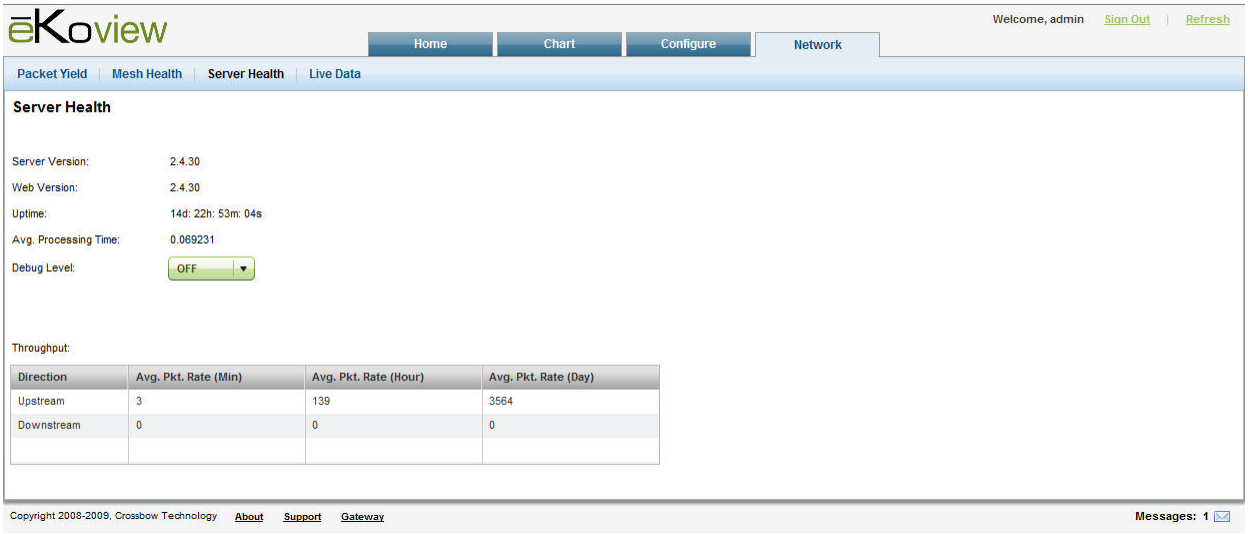
Crossbow's mesh networking software using automatic message retries if a neighbor unit does not receive a message. After trying multiple times it will switch to another neighbor. Even if only 50% of the messages are received by a neighbor this retry capability may still deliver 100% of all messages forwarded.

6.5.3 Server Health Page

The Server Health page displays information about the XServe server running on the ēKo gateway. The following fields are displayed:

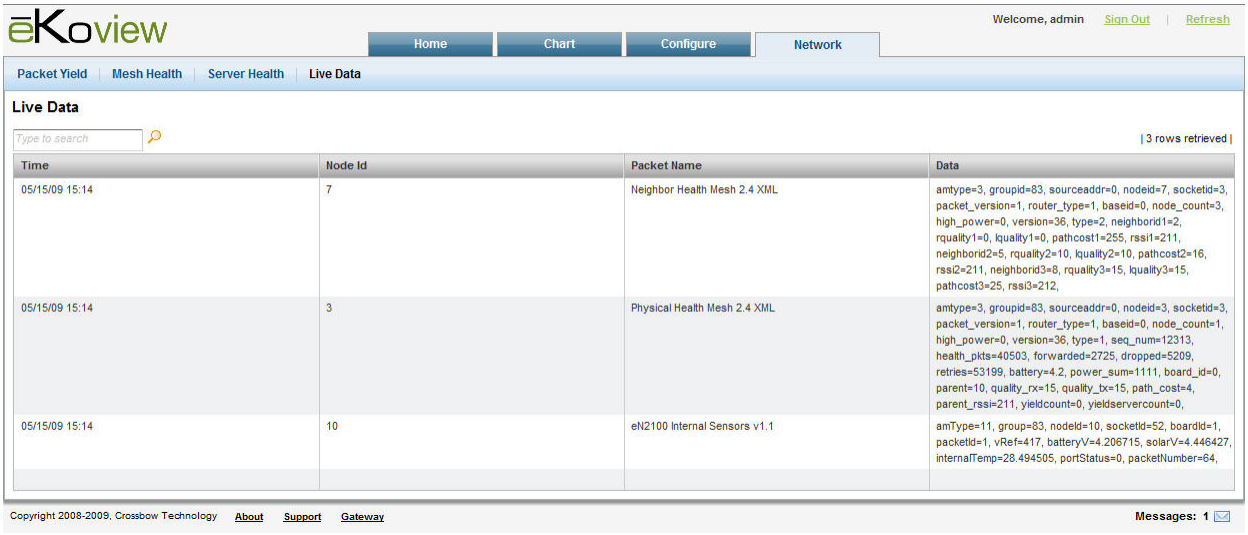
- Version: This current firmware version of XServe.
- Uptime: The length of the time the server has been up and running.
- Average Processing Time: The average time the server spends processing events in seconds.

- Throughput: This table displays the average number of packets coming in from the mesh network and going out to the mesh network.



6.5.4 Live Data Page

The Live Data page in the ēKoView provides a tabular, searchable view of the live data from the sensor nodes as they arrive.



The top table displays the current data organized by time, packet name, and reading. The data is continually updated as new data arrives from the mesh. To search for a particular set of data users can type a search string into the top left search text box. As users type the string, the table attempts to match rows which contain that search string.

☑ EXAMPLE

A user wants to know all the current sensor readings from Node 10. In the search box type "Node 10" and the table will only display data from node 10.

☑ EXAMPLE

A user wants to display all Temperature values from throughout the network. In the search box type "Temperature" and only the Temperature sensors will be displayed.

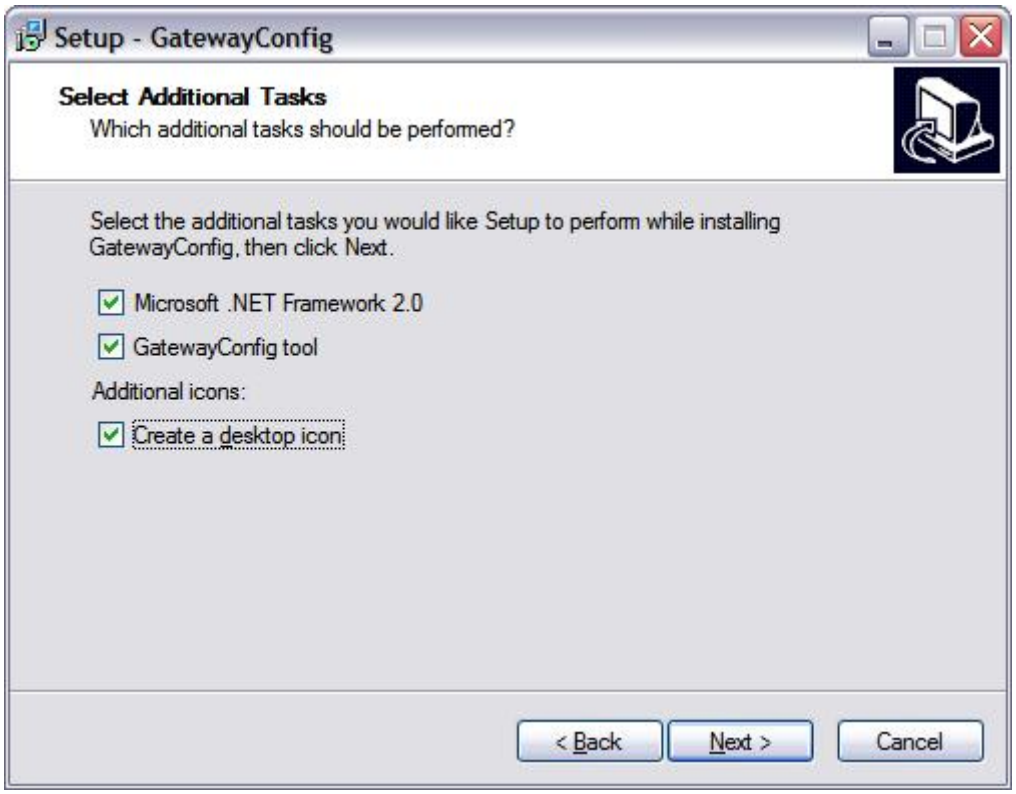
7 Appendix A. Advanced ēKo Gateway Administration

This section describes advanced administration features of the ēKo gateway that involves accessing the Linux operating system running on the gateway.

7.1 GatewayFinder tool to find the IP address of your ēKo gateway

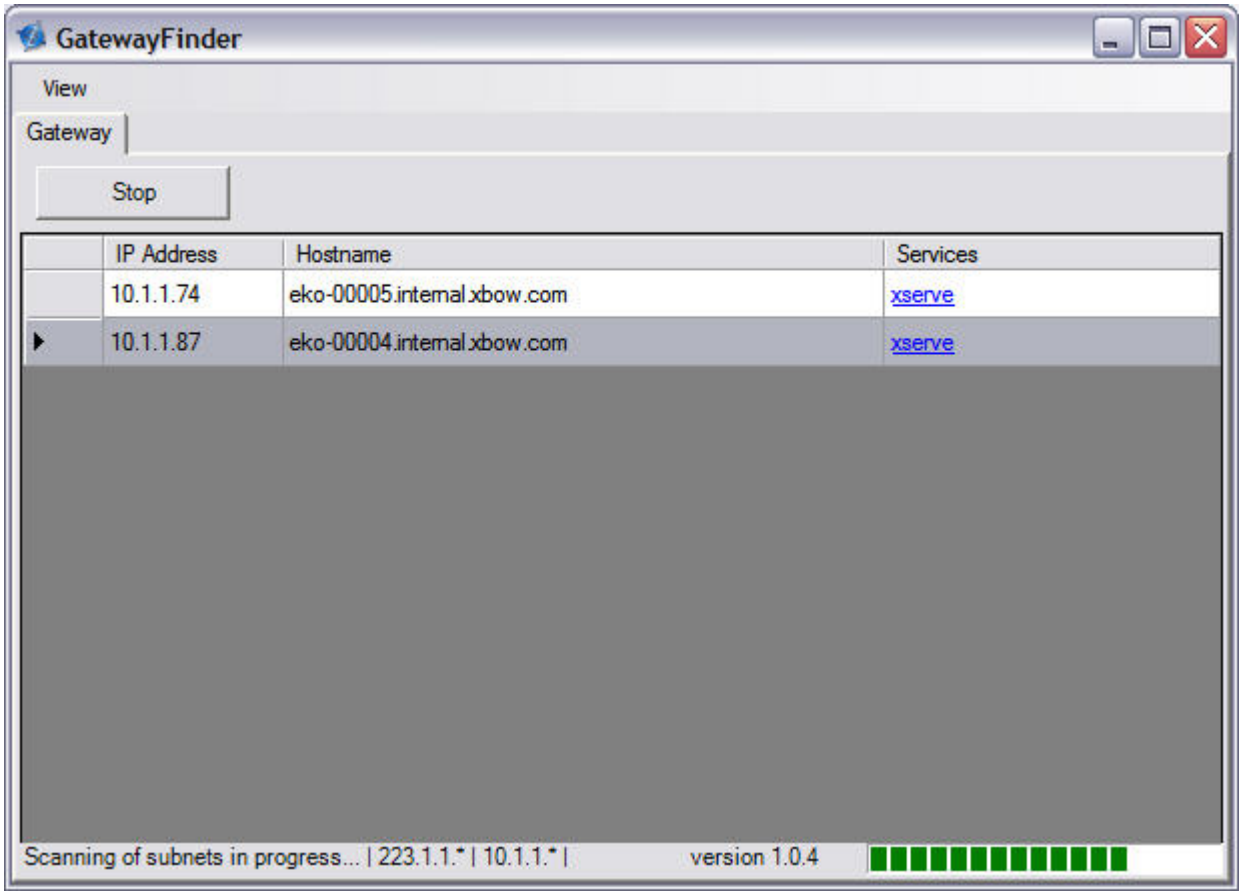
In order to connect to the ēKo gateway its hostname or IP address has to be known. Some networks will resolve the hostname properly so knowing the gateway's IP address is not required. Most home routers do not support the means to use the hostname. In those cases users will need to use the IP address of the ēKo gateway device. The GatewayFinder tool can help scan and find the IP address.

1. The hostname is determined by the prefix *eko-xxxxx* where xxxxx is the 5-digit serial number that can be found on the sticker attached to the bottom of the device (e.g., SN = 00006 -> hostname is *eko-00006*).
2. Install GatewayFinder by double-clicking on *GatewayFinderSetup_<version>.exe* file found on the CD.
3. The Setup wizard would guide you through the installation process. Make sure to check all the installation options (you will need Microsoft .NET Framework 2.0)

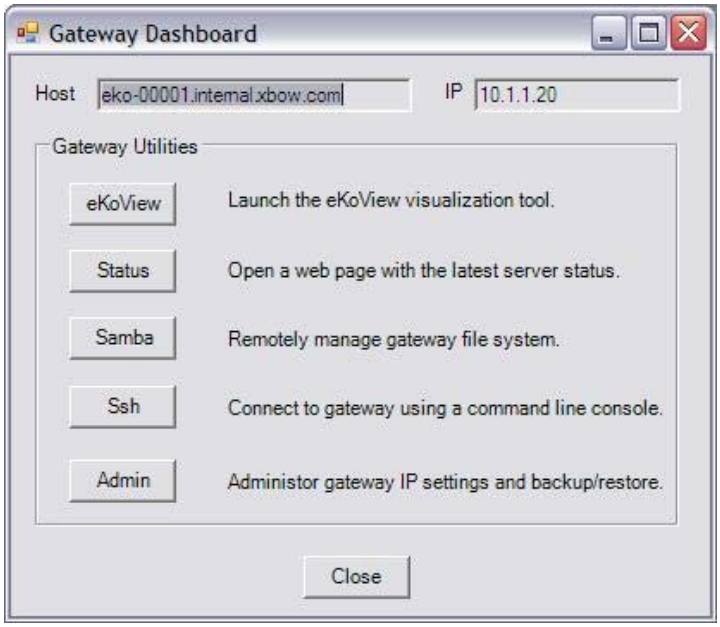


4. Run GatewayFinder from Windows **Start>Programs>Crossbow>GatewayFinder**.
5. In the GatewayFinder GUI, click on **Scan**.
6. Allow sometime for the scanning to complete and the GUI would display a list the ēKo gateway gateways that were found in your network.

7. Make a note of the IP address assigned to your hostname.



8. Clicking on the xserve link for this IP address will open up a Gateway Dashboard window shown below. It offers the following gateway shortcut utilities.



- eKoView – launches the ēKoView login page in a browser window (Section 6.1).
- Status – opens a web page with latest server status details.

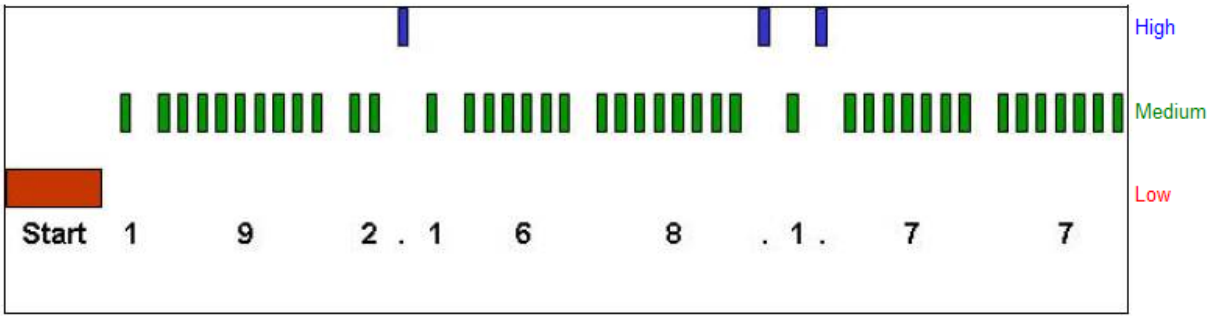
- Samba – allows browsing files on the ēKo gateway via Windows Explorer interface (Section 7.2.2).
- Ssh – connects to the ēKo gateway using secure shell command interface (Section 7.2.1).
- Admin – launches login page for gateway administration and database management (Section 7.3).

A final way to find the IP address of an ēKo gateway is to listen to its beeping sequence at the end of the boot-up period. This sequence can be interpreted as follows:

- A low sound is emitted for two seconds to indicate the start of the sequence
- A set of medium beeps are emitted for each number in the IP address, e.g., "1" causes one beep, "2" two beeps and so on. "0" is expressed as ten beeps.
- A high beep is emitted for each "." In the IP address

☑ EXAMPLE

This is the beep sequence for the IP "192.168.1.77":



7.2 Remote ēKo gateway Administration

The remote gateway administration requires the Linux user name and password. There are two main predefined logins.

User Name	Password	Notes
user	<Refer to CD sticker>	Standard user login
root	<Refer to CD sticker>	System privileged login

Most tasks can be accomplished using the "user" account which should be the standard way of logging in. Some specific tasks require "root" privileges. Special care should be taken when using the "root" account as mistakes can render the system unstable or inoperable.

IMPORTANT: The remote gateway administration login information is different from the eKoView web administration and the passwords can be found on the sticker attached to the CD-ROM included in your ēKo gateway package.

7.2.1 Access using ssh

A remote terminal that supports the Secure Shell (ssh) protocol can be used to log directly into the ēKo gateway. The actual ssh invocation varies between different ssh clients. For UNIX

systems the command is typically of the form "ssh *username@hostname*". The default ssh port is 22. Typically, it is not necessary to be familiar with the underlying Linux operating system to use the ēKo gateway as it comes pre-programmed for its intended use as a Sensor Network gateway. The ēKo gateway is running a recent Debian Linux kernel. Users familiar with Debian can utilize all its features on the ēKo gateway as it conforms to the regular Debian setup. Note that the ēKo gateway is running on an ARM architecture CPU in "little-endian" mode.

For users who are unfamiliar with Linux, here are a few useful commands to get started:

`cd [dir]`	- switch to the directory *dir*
`df`	- list the active file systems and their capacities
`du –s [dir]`	- list the total size of all files in the directory *dir*
`dmesg`	- display the most recent boot log
`dselect`	- select packages to install into system (requires root access)
`ls`	- list the content of the current directory
`lsusb`	- list all attached USB devices
`passwd`	- change login password
`ps aux`	- list all active processes
`rm file`	- delete a file
`rmdir dir`	- remove an empty directory
`top`	- live update on running processes, use "q" to quit
`vmstat`	- list current memory usage
`w`	- list who is logged in

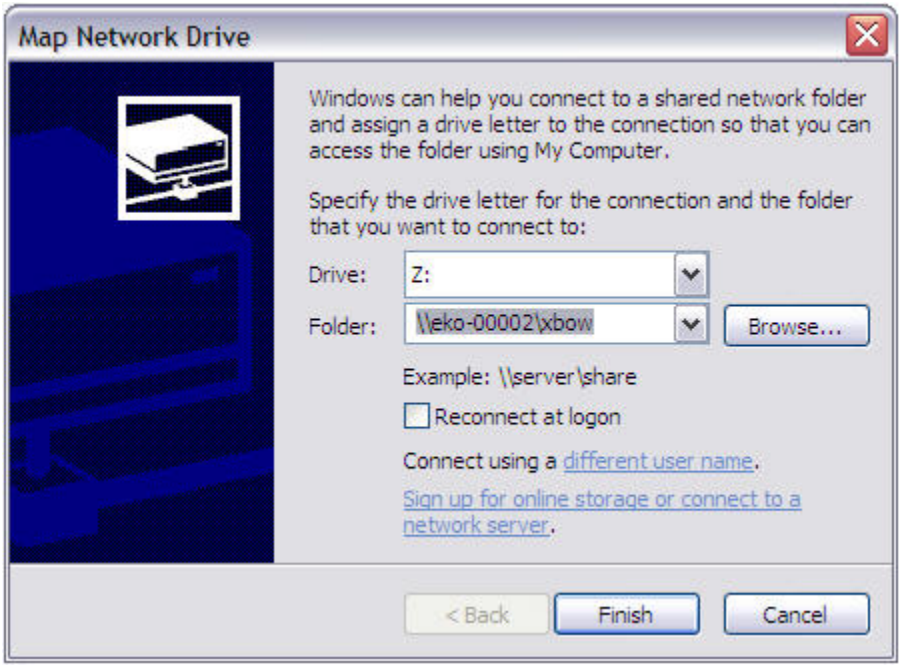
7.2.2 Access using Samba

ēKo gateway uses Samba (Windows File Sharing) to enable transfer of files between ēKo gateway and a PC. You can use Samba to map ēKo gateway directories to your PC (or you can use ssh and scp if you have Linux) and transfer ēKoView configuration files.

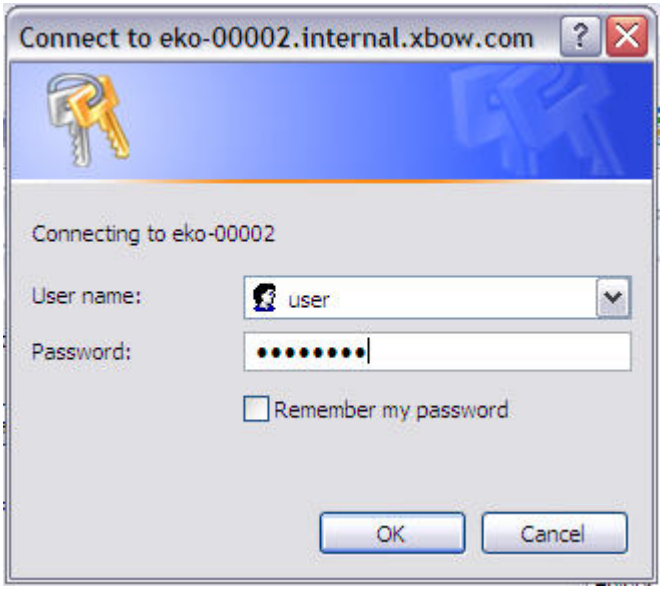
NOTE: For security reasons File Sharing is disabled by default. Refer to section 7.3.5 on how to enable it via the Gateway Administration page. It is highly recommended to place the ēKo gateway behind an Internet firewall. Never enable File Sharing if the gateway is directly connected to the Internet.

To use Samba:

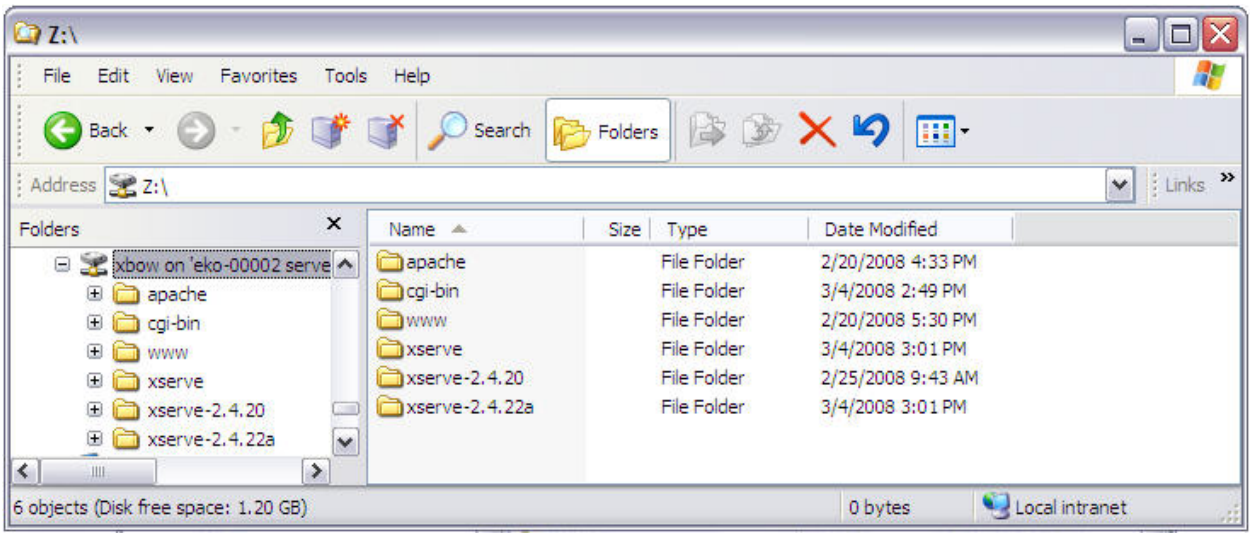
1. Start Window's Explorer and select the "Map Drive" icon which brings up the screen below.
2. Type in \\eko-xxxxx\xbow (use your ēKo gateway's number in place of xxxxx) and click on **Finish**.



3. This will bring up the following screen. Type in "user" as the user name and use the password shown above in section 7.1.1. Then select OK. Then select "Finish"



4. Once your PC has connected the file directory on ēKo gateway will appear as a mapped drive on your PC



Once the file manager window opens the ēKo gateway window, the files in the /usr/xbow directory can be read or written.

NOTE: The modification of files in this directory can cause XServe and/or ēKoView to stop functioning correctly. Should this happen, individual files or the entire contents of this directory can be restored from the (read only) "backup" subdirectory.

7.3 Access using Gateway Administration Page

7.3.1 Assigning Static IP address

The ēKo gateway is factory configured for DHCP (dynamic IP address). Alternatively, it defaults to the static IP address 192.168.1.77 if a DHCP address can not be obtained (after 60s). If a different static IP address is desired it will need to be reconfigured using the procedure described below.

NOTE: In order to change the IP configuration the ēKo gateway will first have to be brought up using either the DHCP or default static address. For the later case make sure that no other machine occupies this address.

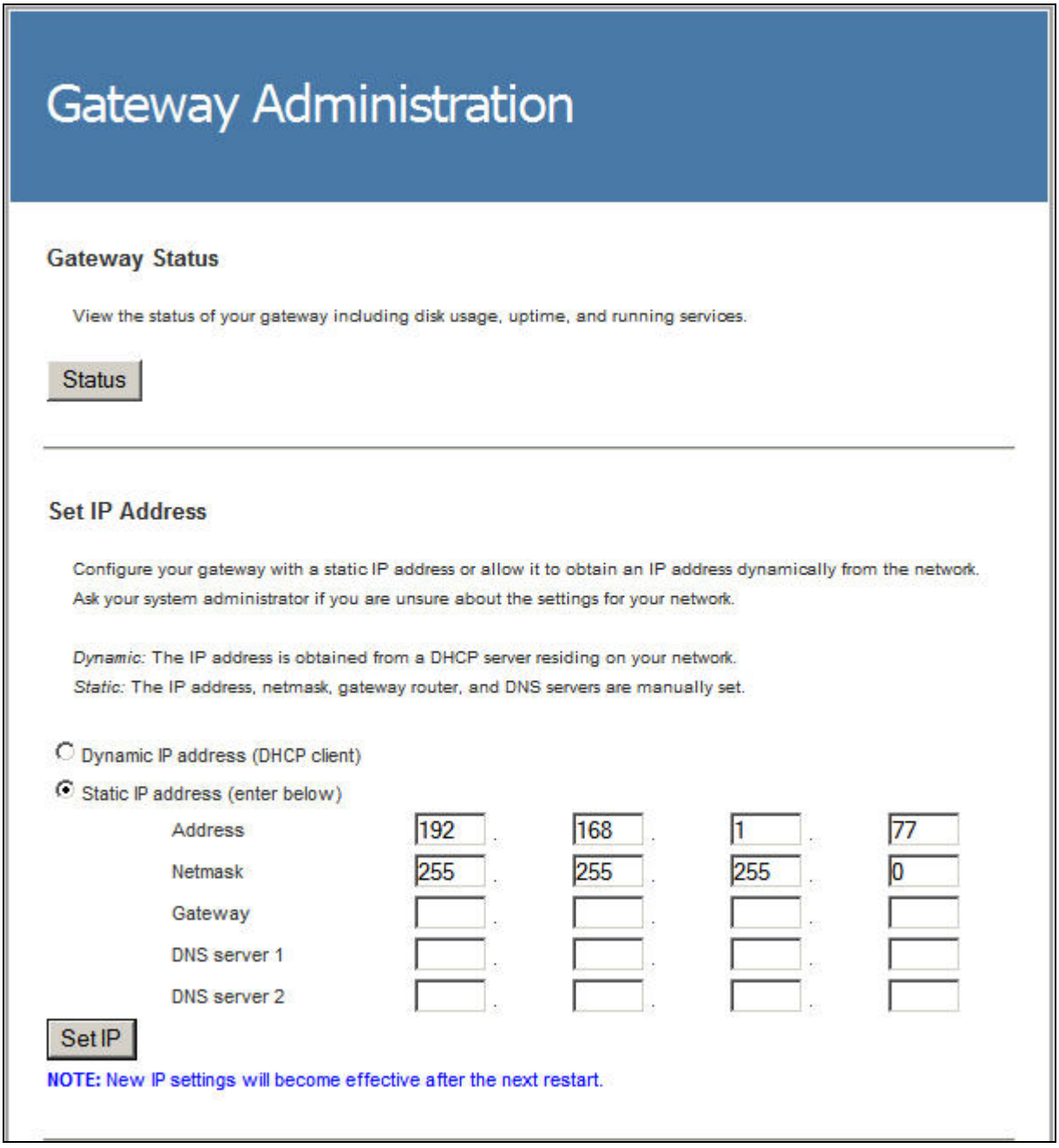
1. Log into the ēKoView interface.
2. Open the ēKo gateway administration page by clicking on the "**Gateway**" link at the bottom link.
3. You will be prompted for login. Login using "**user**" account.

NOTE: If you have the pop-up blocker enabled on your browser, you may have to allow it to open pop-ups for the ēKoView page.

4. This should bring up the Gateway Administration page in a separate browser window.
5. Check on the Static IP address radio button.
6. Specify at a minimum the static IP address and netmask fields. Ask your system administrator if you are unsure about the settings specific to your network.
7. Click on **Set IP** button.
8. Restart the ēKo gateway by pressing the **Restart** button at the bottom of the Administration page, it will boot with the new static address.

⚠ WARNING

Make sure that the IP settings are correct as it is difficult to recover from a mistake. If you loose the ability to connect to your gateway after setting an incorrect fixed IP, you can use the method in section 7.3 to recover.

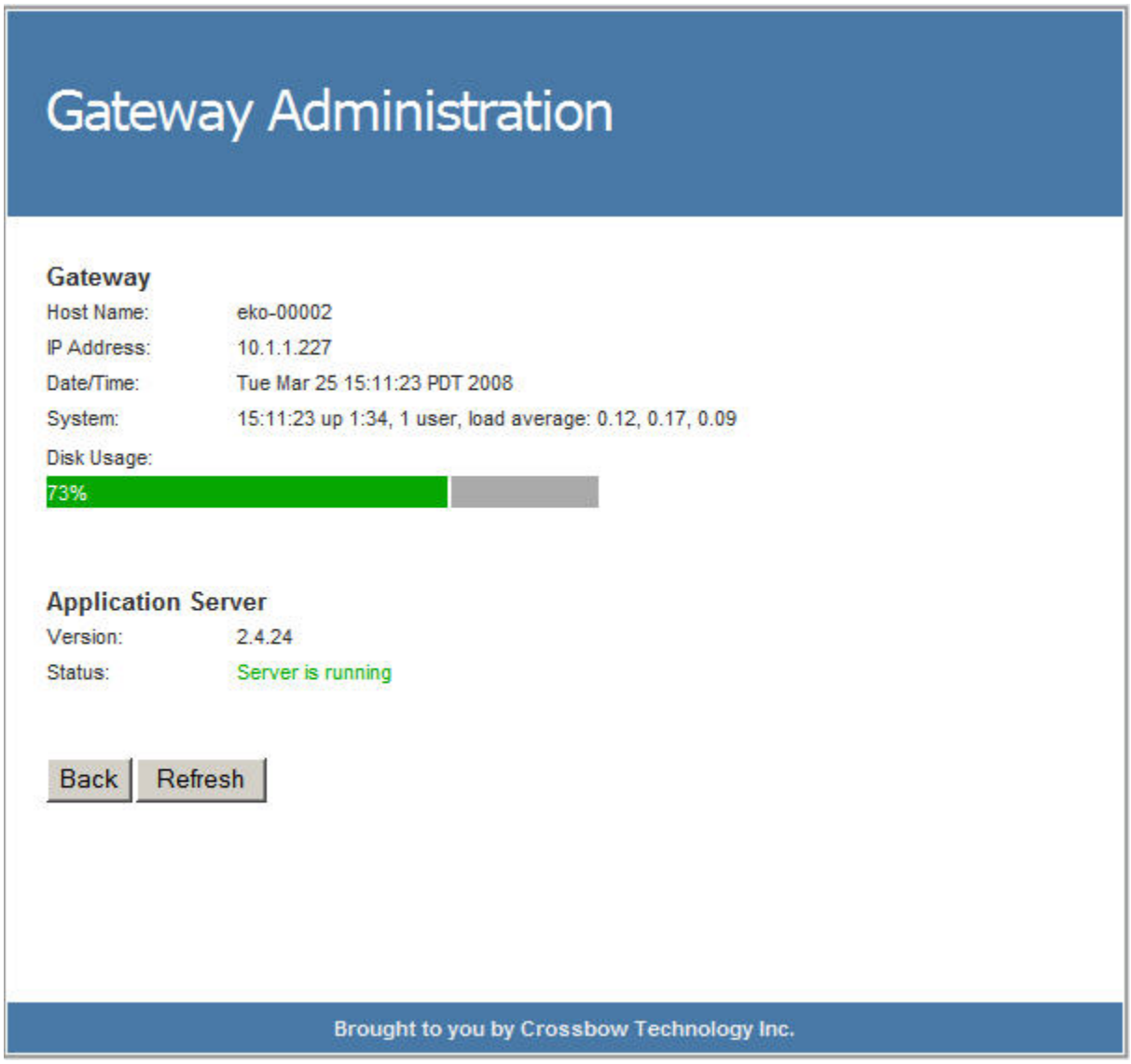


NOTE: The above numbers are examples; replace those with ones appropriate for your network.

7.3.2 Viewing the ēKo Gateway status

The Gateway Administration page has a "View Status" feature at the top. Clicking on "**Status**" button will show a status page as shown below.

IMPORTANT: Ensure that the disk usage does not exceed 90%. In that case a warning will be displayed and the bar will turn red. To free up disk space, see the database management in section 7.3.7 below.



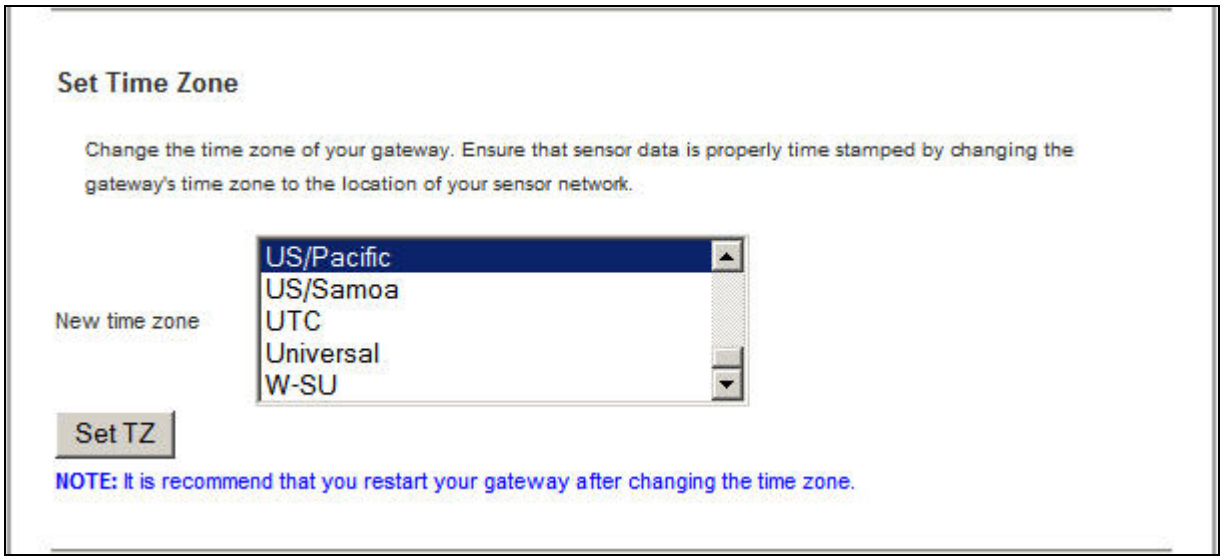
7.3.3 Changing the ēKo Gateway hostname

The ēKo Gateway ships pre-configured from the factory with the host name "eko-xxxxx" where xxxxx is the serial number specified on the sticker at the bottom of the ēKo Gateway. The ēKo Gateway Administration allows user to change this default name: Type the new host name in the text box and click on **Rename**. Restart the ēKo gateway by pressing the **Restart** button at the bottom of the Gateway Administration page, it will boot with the new hostname.

NOTE: No spaces or special characters are allowed for the host name. Use alpha numeric characters only.

7.3.4 Changing the ēKo Gateway time zone

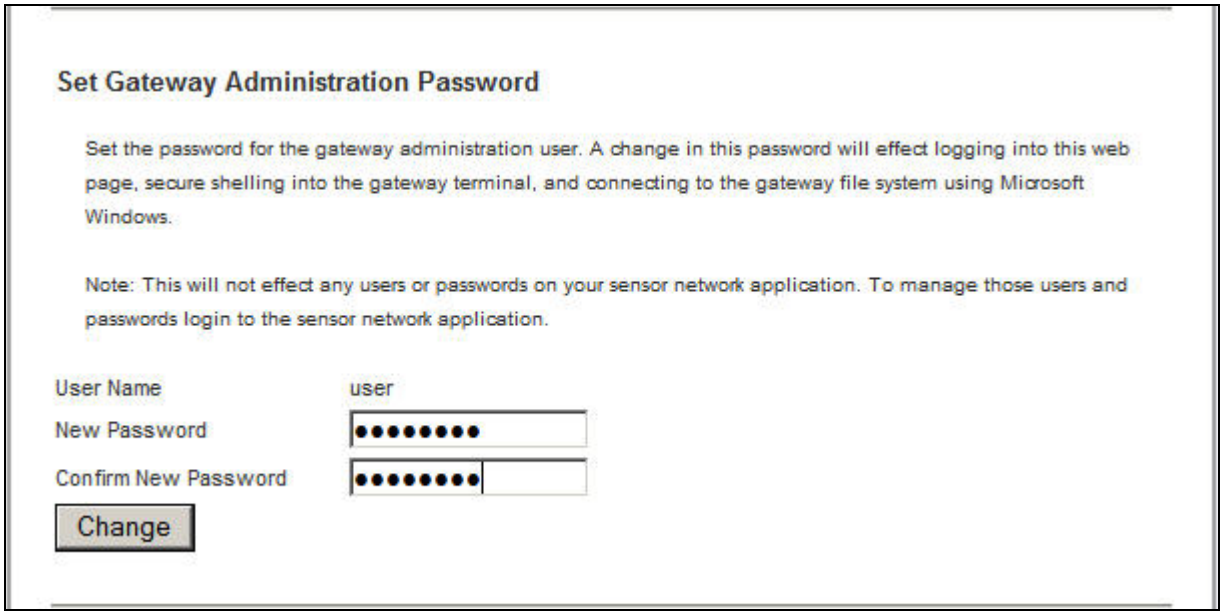
The ēKo Gateway ships pre-configured from the factory with US Pacific time zone. Since the data is time-stamped relative to the time zone, users may want to change this to their time zone. The ēKo Gateway Administration allows user to change this default time zone: Select the time zone from the scroll list and click on **Set TZ**. The time zone change will be effective immediately.



7.3.5 Changing the ēKo Gateway administration password

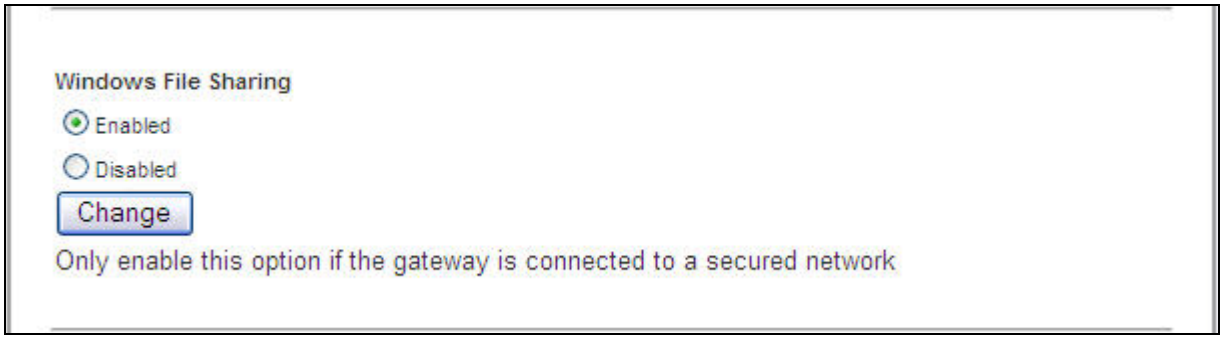
To set the password for the gateway administration user, input the new password, confirm it and click on **Change**. A change in this password will affect logging into this web page, secure shell (ssh) into the gateway terminal, and connecting to the gateway file system (Samba) using Microsoft Windows explorer.

◀ **NOTE:** This will not affect any users or passwords for ēKoView web access. To manage those users and passwords refer to section 6.4.3.



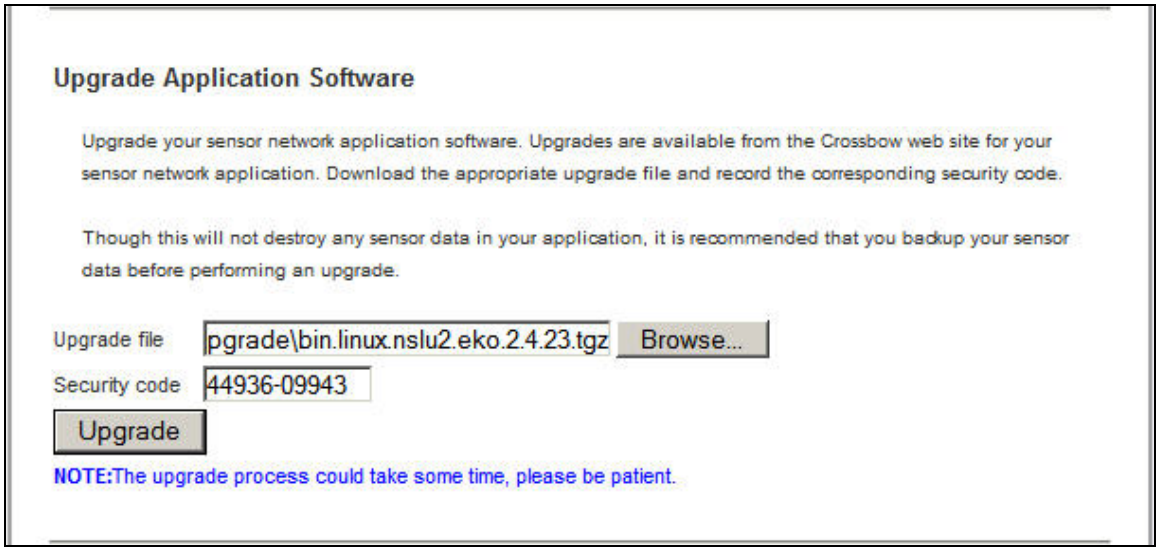
7.3.6 Enabling windows file sharing on the ēKo Gateway

The ēKo Gateway is configured to disable file sharing by default for security reasons. If you are on a secured network you can enable it by selecting on Enabled radio button and clicking on the **Change** button.

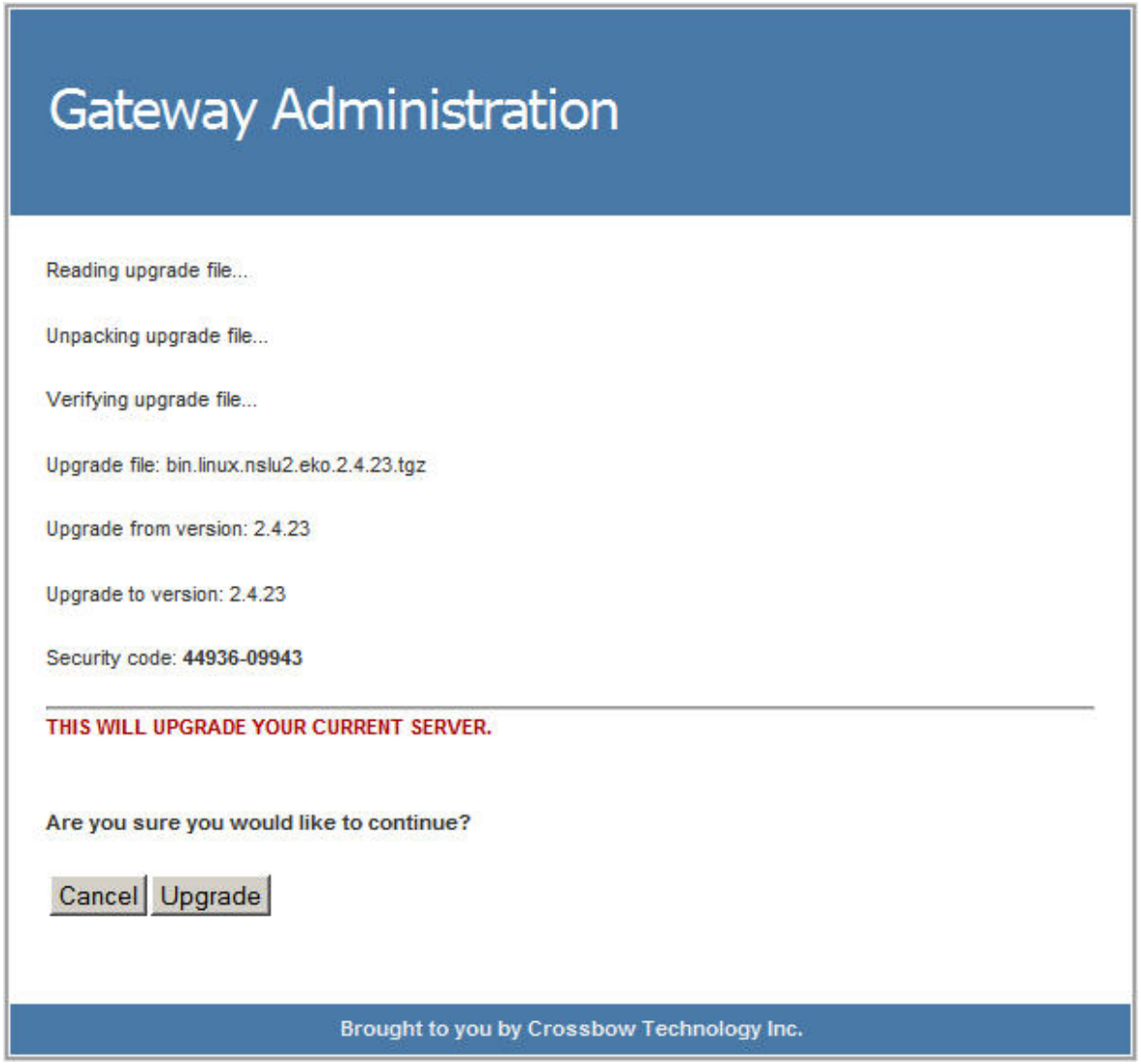


7.3.7 Upgrading the ēKoView Software

Crossbow may periodically provide an upgrade file to enable new functionality, fix bugs, etc. You can download this file from Crossbow's support site (http://www.xbow.com/eko/TechSupport.aspx) to your PC. Each update will have a security code associated with it to verify its integrity. Use the following feature to upgrade your gateway.



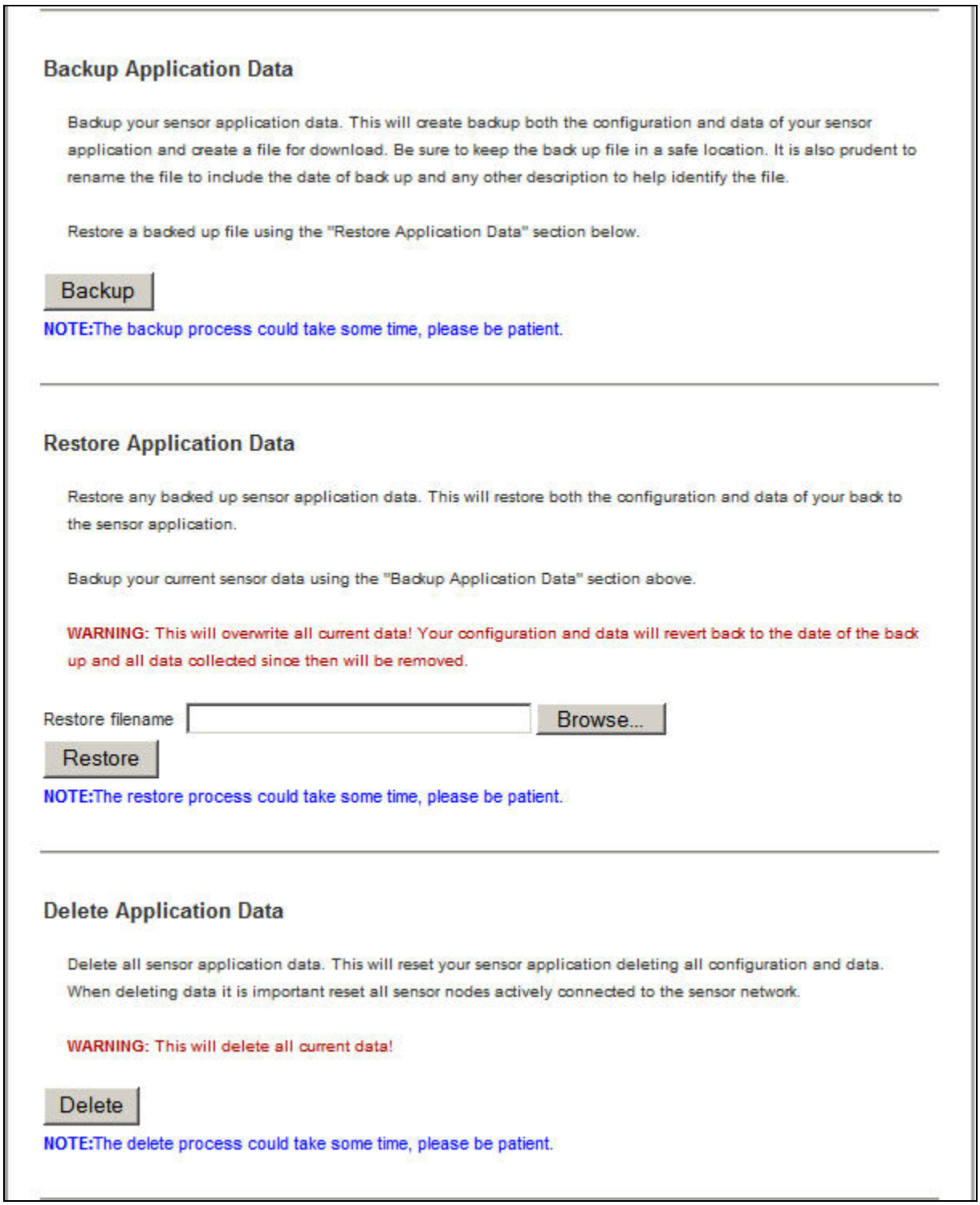
Select the upgrade file that you have downloaded to your PC using the "**Browse**" button. Enter the associated security code in the field below. The format is always xxxxx-xxxxx. Press the "**Upgrade**" button and following dialog window will appear.



It will display you the current version and the new version info. Click on **Upgrade** button to continue. The upgrade process will take few minutes. Wait for the "UPGRADE COMPLETE" message and then click on "**Done**".

7.3.8 Managing database

The Gateway Administration page provides several utilities to manage your data. Those include backup, restore and delete database functions.



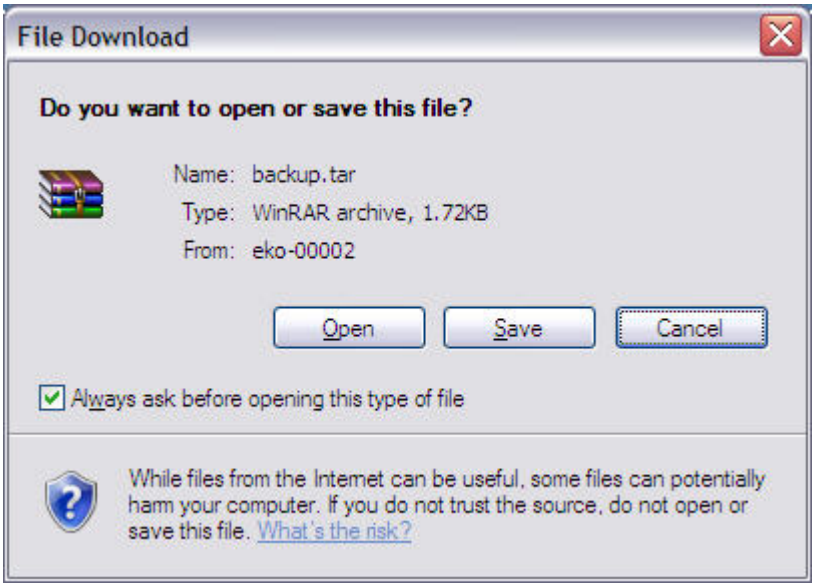
⚠ WARNING

Incorrect use of the "Delete Application Data" and "Restore Application Data" functions can destroy all your data. Always use the "Backup Application Data" function first and archive those backups on your PC.

NOTE: There will be an initial delay when using any of the functions above as the Gateway has to temporarily halt normal data collection to ensure database integrity. Normal operation will resume after the functions complete.

Clicking on the "**Backup**" button will provide a link to enable saving your database to your PC. Click on "**Data Backup**" link to save it on your PC.

Click on "**Save**" and specify the path on your PC. After the save operation is complete be sure to press "**Continue**" to resume normal data collection mode.



NOTE: It is highly recommended to copy your saved database to a separate backup directory on your PC, ideally named with the date of the backup, i.e., copy "backup.tar" to "backup.010108.tar".This way you will be able to distinguish different backups.

IMPORTANT: If your disk usage exceeds 90% you will have to backup your current database to your PC and delete it from the ēKo Gateway to ensure continued proper system operation. If the disk becomes 100% full the system will not be able to log further data and may become unstable.

To restore database to a previously saved database, click on "**Browse**" and select a database file from your PC. Click on "**Restore**" button to restore it to the gateway.

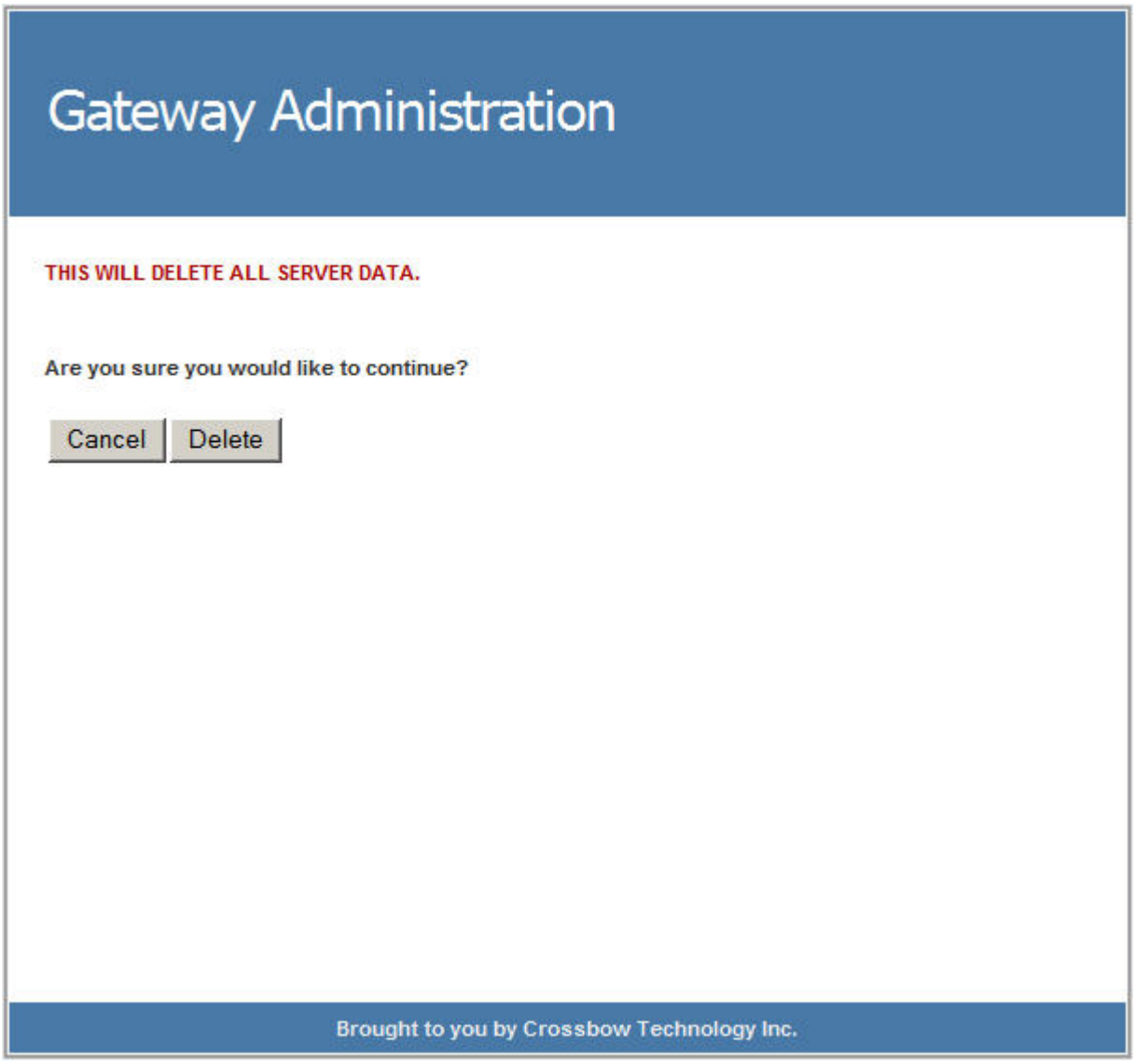
⚠ WARNING

"Restore" operation will overwrite all your current data. Your configuration (such as node placement, background map image, node name, and ēKoView login/password) and data will revert back to the date of the back up and all data collected since then will be removed.

To delete database, click on "**Delete**" button and a confirmation dialog will appear.

⚠ WARNING

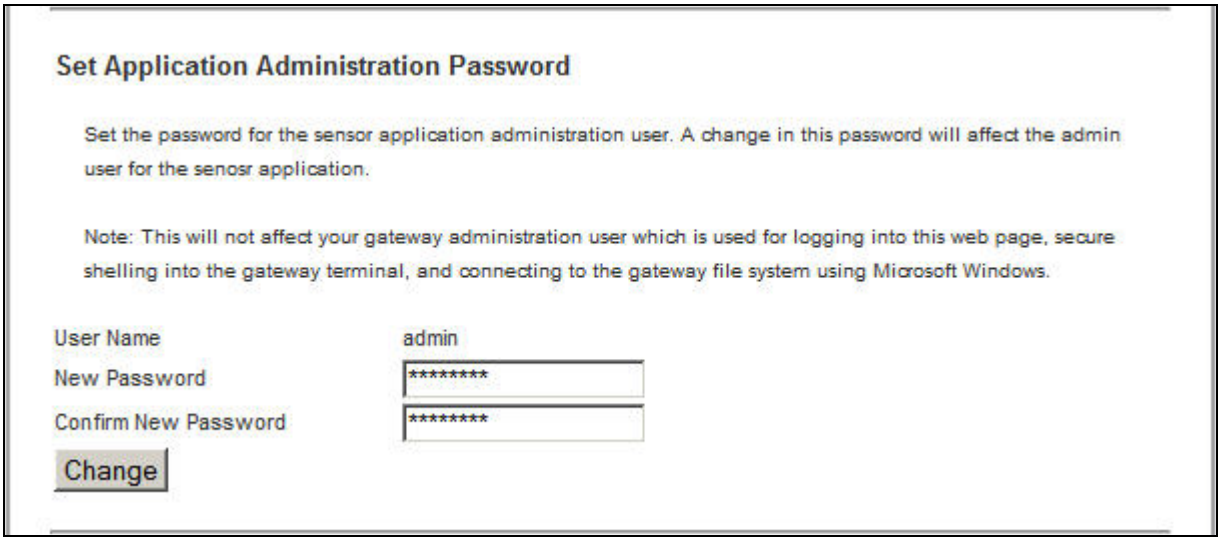
The "Delete" operation will erase all the information associated with the nodes from the gateway server. Once you exercise this option, you will need to bring the nodes near the gateway and re-commission them.



7.3.9 Changing the ēKoView administration password

To set the password for ēKoView administration user ('admin'), input the new password, confirm it and click on **Change**. Although this can be accomplished from the "Manage Users" page of ēKoView (refer to section 6.4.3), this page can be used to reset the admin password should you forget it completely.

NOTE: This will not affect gateway administration user which is used for logging into this web page, secure shell (ssh) into the gateway terminal, and connecting to the gateway file system (Samba) using Microsoft Windows explorer.



7.4 Commercial networks

In commercial environments routed sub-nets are commonly deployed. This can create difficulties in initially identifying the ēKo gateway's DHCP address with the GatewayFinder tool as it does not know about non-local subnets. In this case it is recommended to run the GatewayFinder tool (section 7.1) on a machine that is on the same subnet as the ēKo gateway or consult your system administrator. Often, commercial networks link DHCP and DNS which will allow connecting to the ēKo gateway by its name without knowing its IP address. There is usually a time delay (varying widely by network type) before the hostname is visible in DNS after the initial boot-up.

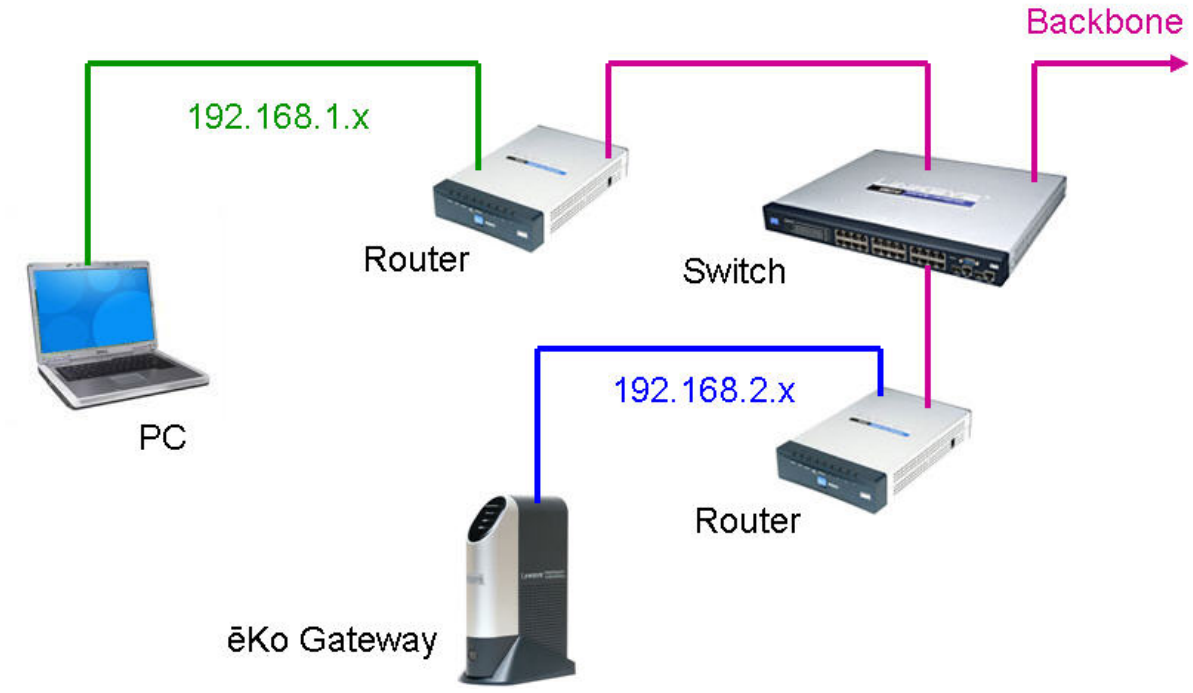


Figure 7-1. Multi-network configuration

7.5 Configuring Remote Internet Access for the ēKo Gateway

For remote internet access to the ēKo Gateway through a firewall do the following:

1. Determine the IP address of the router and the ēKo gateway.
2. Log into your router's we page (refer to your router's manual)
3. Enable and open the following ports on the router for the ēKo Gateway

   Port 9003 for XCommands

   Port 9005 for xml stream

   Port 9080 for HTTP

   Port 9843 for Flash player security
4. Save these settings and reboot the router
5. The remote internet access to ēKoView will be available through the following URL

   http://<Router IP address>:9080

☑ EXAMPLE

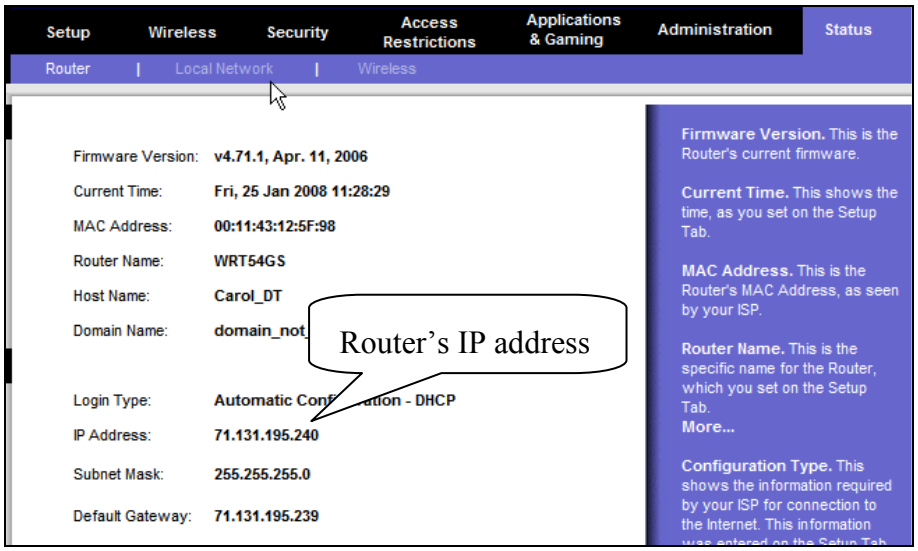
If you are using Linksys home router, follow these steps.

Log into the router's webpage

Open a web browser and type the IP address of your router in the address bar. (By default, the IP address should be set to 192.168.1.1). Consult your router's user manual for details.

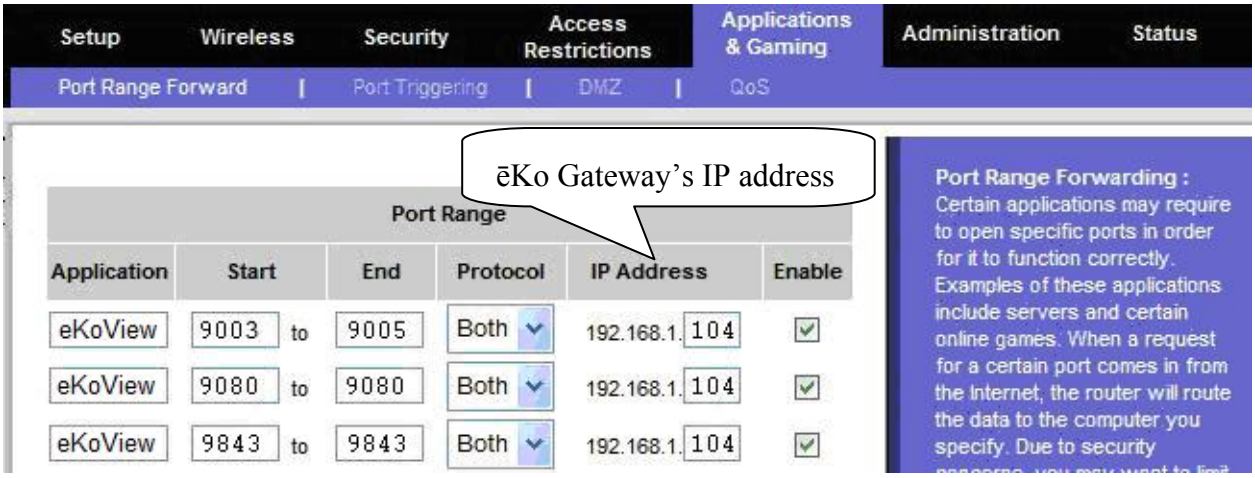
Determining the IP of the router

For Linksys routers access the Status page to see the IP address (71.131.195.240 in the example below).



Enable and open the ports

For Linksys routers, access the "Applications & Gaming" page and click on **Port Range Forward** link.



- Enter the name of the program into the **Application** box (eg. eKoView). It doesn't really matter what you put into this box, but something that will remind you why these ports are being forwarded would be a good idea.
- Enable the following range of ports (If you are forwarding a single port, enter that port number into the **Start** and the **End** boxes. If you are forwarding a range of ports, enter the lowest number of that range into the **Start** box. Then enter the highest number of that range into the **End** box)

  9003 to 9005

  9080 to 9080

  9843 to 9843
- Specify the IP address of the ēKo Gateway in **IP Address** box. (192.168.1.104 in the example below).
- Put a checkmark in the **Enable** checkbox.
- When you are finished, click **Save Settings** button near the bottom of the screen.

For the above example, remote access to ēKoView will be available through the following URL http://71.131.195.240:9080

The following website provides step-by-step procedure on how to set-up port forwarding for an extensive list of routers.

http://www.portforward.com/english/routers/port_forwarding/routerindex.htm

Refer to your router's user's manual for further details.

7.6 Using a smart UPS

The ēKo Gateway supports smart UPS devices from APC that feature a USB connection. If this feature is used, the Gateway will automatically shut down when the batteries are critically low. In order to use this feature, a USB hub is needed. The upstream port of the hub should be connected to the USB slot labeled "Disk 2" of the Gateway (using the USB cable provided with the hub). The ēKo base radio will then be plugged into one of the downstream ports of the hub (using the cable provided with the base radio). The cable from the UPS will be plugged into another downstream port of the hub (using the cable provided with the UPS). Refer to Figure 7-2

for the connection diagram. Any USB 1.1 or 2.0 compliant hubs should work. The hub does not need to be self-powered.

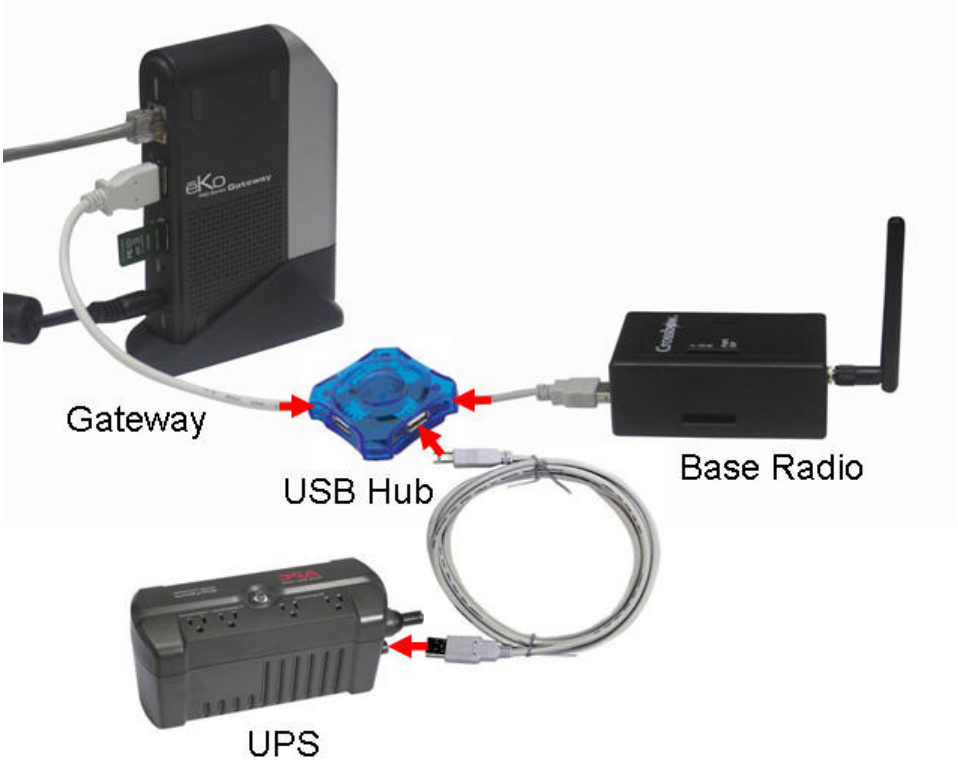


Figure 7-2. Smart UPS connection diagram

⚠ WARNING

Do not plug the hub into USB slot labeled "Disk 1" of the ēKo Gateway. This port is reserved for the system disk which should always be directly plugged into the gateway.

8 Appendix B: ēKo Sensors

8.1 eS1101 Soil Moisture & Soil Temperature Sensor

The eS1101 sensor consists of a Watermark soil moisture sensor and soil temperature sensor which temperature compensates the Watermark sensor. Up to four eS1101 ēKo sensors can be connected to one ēKo node to measure soil moisture at different soil depths.

8.1.1 Installing the Sensor

If time permits soak the soil moisture sensors overnight and install wet. Make an access hole for the soil moisture sensor to the desired depth with a 7/8"diameter rod. The depth depends on the root zone of the crop. Fill the hole with water and push the sensor down into the hole so it "bottoms out". Backfill the hole with soil until the sensor is covered a few inches. Push the temperature sensor down then continue to backfill with soil until both sensors are buried.

For very coarse or gravelly soils, an oversized hole (1" – 1-1/4") may be needed to prevent abrasion damage to the soil moisture sensor membrane. In this case, auger a hole to the desired depth and make a thick slurry with the soil and some water. Fill the hole with this slurry, install the soil moisture sensor then the temperature sensor. This will "grout in" the soil moisture sensor to ensure a snug fit.

IMPORTANT: Installing a "dry", unconditioned soil moisture probe may result in erratic/invalid readings for a number of days until the probe absorbs water/equilibrates with the soil. This is the reason for "conditioning" the probes before burial.

8.1.2 Sensor Maintenance

The Watermark sensor is manufactured from non-corrosive parts which will last for years. Once the sensors are installed, there is no future need for maintenance. With permanent crops such as trees and vines, the sensors may be left in place all winter. With annual crops, where field operations are required, removing the sensors prior to harvest is a standard practice. If the sensors are removed, simply clean them off and store them in a dry area until spring.

8.1.3 How does the soil moisture sensor work?

The sensor consists of two concentric electrodes buried in a special reference matrix material that is held in place by a stainless steel case. The matrix material has been selected to reflect the maximum change of electrical resistance over the growth range of production crops. Soil moisture is constantly being absorbed or released from the sensor. As the soil dries out, the sensor moisture is reduced and the electrical resistance between the electrodes is increased.

The Watermark provides accurate readings from 0 to 200 centi bars. This covers the entire soil moisture range required in irrigated agriculture, even in the heavier clay soils. The Watermark does not dissolve in the soil like a gypsum block. However, it does include internally installed gypsum which provides some buffering for the effects of salinity levels normally found in irrigated agricultural crops and landscapes. Because they are unaffected by freezing temperatures, Watermark sensors do not require removal during the winter months in cold climates.

8.1.4 What does the sensor reading mean?

The Watermark measures soil water tension or suction which is a direct indicator of how hard the plant root system has to work to extract water from the soil. The drier the soil, the higher will be the reading. By monitoring the sensors between irrigations, it is possible to measure the rate at which the soil is drying out. The "rate of change" is as important as the actual reading in determining when to irrigate to avoid moisture stress.

8.1.5 Determining "When' to Irrigate

Figure 8-1 shows how variations in soil affect the ability of the soil to store water (water holding capacity).

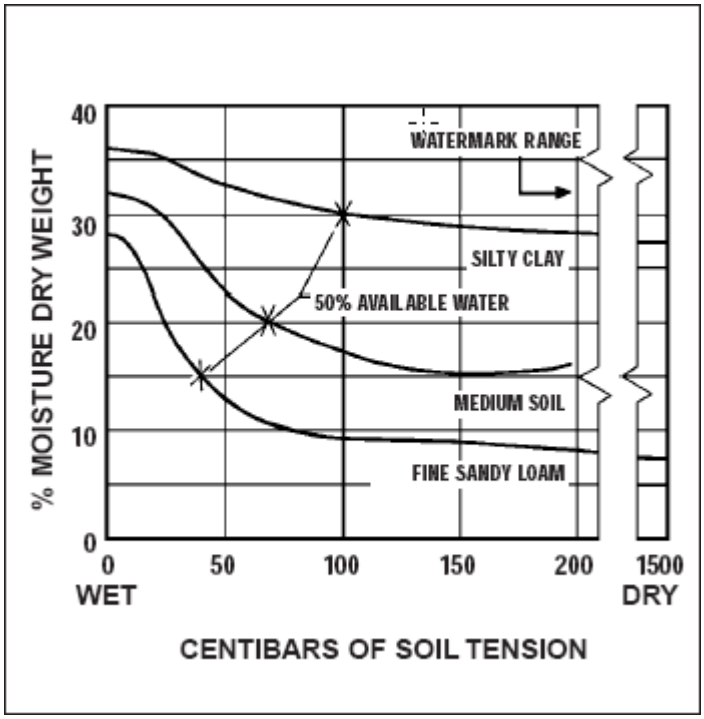


Figure 8-1. Water holding capacities of different soil types

Heavier clay soils store much more water than sandy soils. But even more important, the plant cannot readily extract all of this stored moisture, only the "available" portion. The general rule of thumb is that irrigation should commence before reaching 50% of the "available" portion being depleted. Figure 8-1 shows the soil moisture tension at the 50% level of available moisture.

Assuming a medium type soil, this 50% level would occur at about 60-70 centibars. While determination of the proper irrigation point is largely dependent on soil type, also consider the crop and irrigation method. Sensitive crops may require irrigation sooner; less sensitive crops may not need water until later. Surface irrigation may allow you to apply water much more rapidly than a drip system, thus you need to consider how quickly your system can react in order to avoid moisture stress (See Figure 8-2).

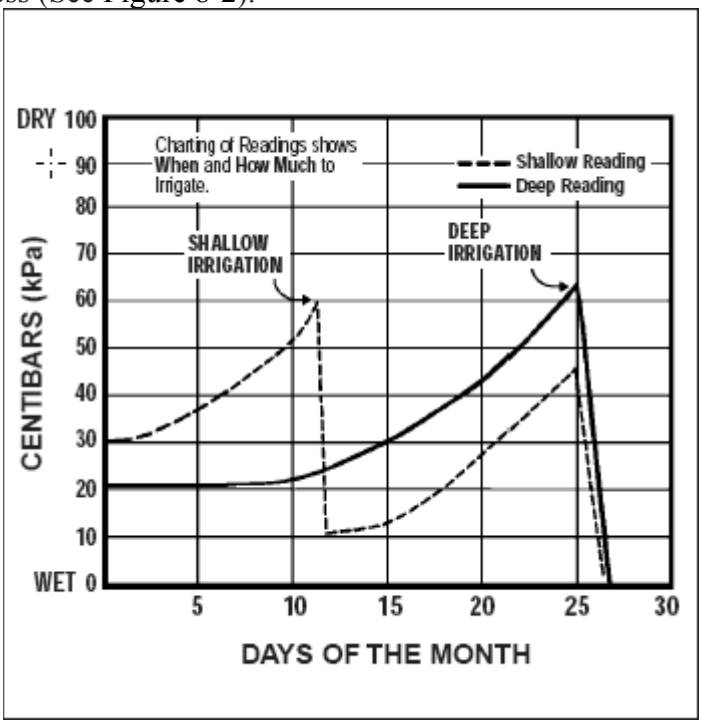


Figure 8-2. Graph showing when to irrigate

8.1.6 Determining "How Much" To Irrigate

Record keeping and experience with the crop, soils and irrigation method are essential with any good management system. With Watermark sensors properly placed in both the top (e.g. 12") and bottom (e.g. 24") of the crop root system, readings will tell whether it is the shallow or deep moisture which is depleted. If the shallow reading is 60 and the deep reading is 10, then apply enough water to rewet the top 12". If the readings are reversed, with 40 for the shallow and 60 for the deep, twice as much water may be needed.

8.2 eS1201 Ambient Temperature and Humidity Sensor

The eS1201 Temperature/Humidity sensor measures relative humidity and air temperature. These readings are also used to calculate dew point. The sensor enclosure protects the sensor from mechanical damage, and a membrane filter protects the sensor elements from dust, dirt, and water spray. The housing includes a cable strain relief.

8.2.1 Installing the Sensor

To ensure accurate readings when measuring outdoor air temperature and humidity, the eS1201 should be shielded from direct sunlight and other sources of reflected or radiated heat. A commercial solar shield such as the Davis 7714 unit can be used. Other inexpensive shields such as PVC tubes can also be used.

Alternatively you may place the sensor in a shaded area so that the opening is oriented downwards. Place the sensor where it is not exposed to direct sunlight and where it will have limited exposure to reflected sunlight. If possible place the sensor at least 5' from any surface which is exposed to direct sunlight and may heat the surrounding air.
Place the sensor at least 10' from lights or lamps and at least 5' from any heat sources such as vents. Limit the exposure of the sensor to open night sky. Areas that are dry in the morning after a light dew should be okay.

NOTE: The temperature sensor of eS1201 is rated to operate from -40 to +60C. If you subject the sensor to outside this range, the readings will be invalid

8.2.2 Sensor characteristics

The eS1201 uses is a single chip, integrated circuit to measure relative humidity and temperature, generating a calibrated digital output. The device includes a capacitive polymer sensing element for relative humidity and a band gap temperature sensor. Both are coupled to a 14bit analog to digital converter.

Air, in our normal environment, always holds humidity. The number of water molecules in the air can vary substantially, e.g. it can be as dry as in a desert or as humid as in the tropics. There is an upper limit for the amount of humidity which air can hold at a given temperature. Beyond this limit saturation occurs. If for some reason the humidity level is pushed up to this limit, condensation occurs and fog or water droplets form. Relative humidity tells you what percentage of this maximum amount of humidity is present in the air. In contrast to relative humidity, absolute humidity denotes the absolute amount of humidity in the air regardless of the saturation level expressed as the total mass of water molecules per air volume.

If temperature rises or falls in a closed system, the saturation vapor pressure will increase or decrease. As a consequence, the relative humidity will drop or rise.

The dew point is defined as the temperature at which the present amount of humidity in the air starts to condensate. It can be calculated by using relative humidity and temperature as inputs.

Figure 8-3 shows the sensor accuracy chart.

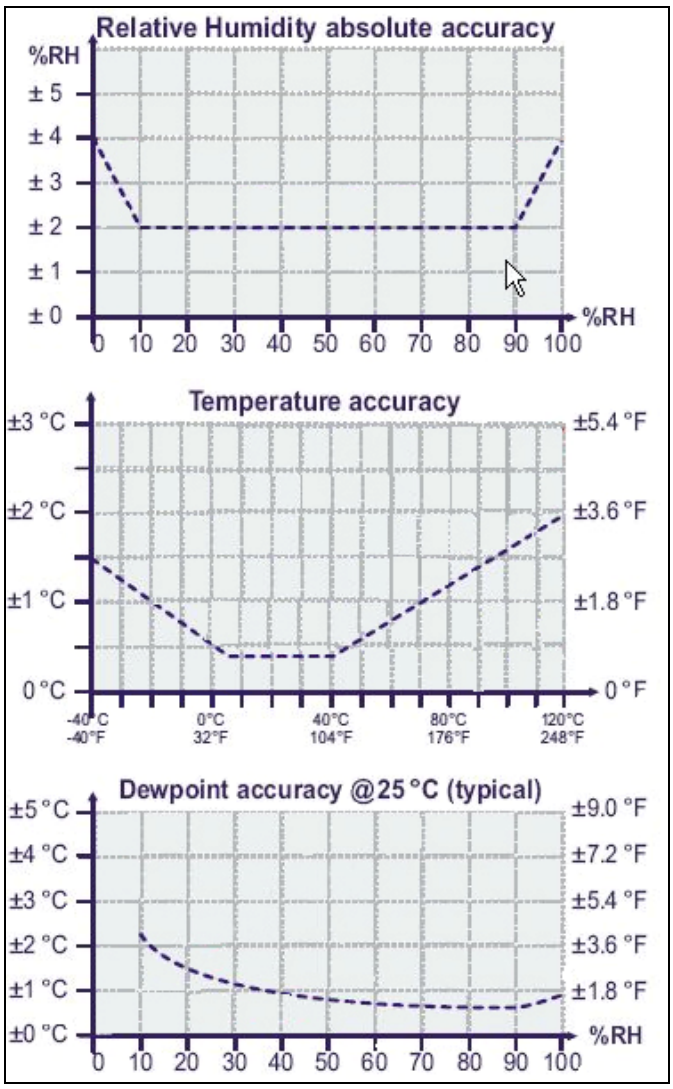


Figure 8-3. Relative Humidity, Temperature and Dew point accuracies

For the theory of operation and installation tips for the other sensors, refer to the sensor vendor's manuals provided with the sensor package.

8.3 eS1110 soil water content sensor

The eS1110 uses the Decagon EC-5 which obtains volumetric water content by measuring the dielectric constant of the media through the utilization of capacitance/ frequency domain technology. It incorporates a high frequency oscillation which allows the sensor to accurately measure soil moisture in any soil with minimal salinity and textural effects.

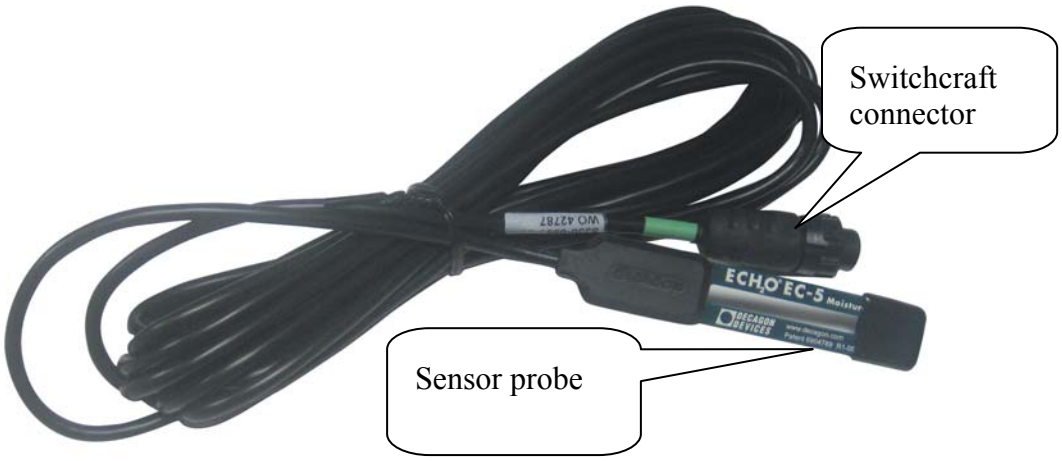


Figure 8-4. eS1110 soil water content sensor

8.3.1 Installing the Sensor

When selecting a site for installation, it is important to remember that the soil adjacent to the probe surface has the strongest influence on the probe reading and that the probe measures the *volumetric* water content. Therefore any air gaps or excessive soil compaction around the probe can profoundly influence the readings. Also, do not install the probes adjacent to large metal objects such as metal poles or stakes. This can attenuate the probe's electromagnetic field and adversely affect output readings. Since the sensor has gaps between its prongs, it is also important to consider the size of the media you are inserting the probe into. It is possible to get sticks, bark, roots or other material stuck between the probe prongs, which will adversely affect readings. Finally, be careful when inserting the probes into dense soil, as the prongs will break if excessive sideways force is used when pushing them in.

You can safely connect up to 200 feet without signal attenuation. For most applications, you will want to seal the connections from the elements to maintain a good connection and to prevent corrosion.

Insert the probes into the soil, making sure that the prongs are buried completely up to the black overmolding. The tip of each prong has been sharpened to make it easier to push the probe in. The probe may be difficult to insert into extremely compact or dry soil. If you have difficulty inserting the probe, try loosening the soil somewhat or wetting the soil. **Never pound it in!** The probe can be oriented in any direction. However, orienting the flat side perpendicular to the surface of the soil will minimize effects on downward water movement.

When removing the probe from the soil, **do not pull it out of the soil by the cable!** Doing so may break internal connections and make the probe unusable.

8.3.2 How does the soil water content sensor work?

The soil water content sensor measures the dielectric constant of the soil in order to find its volumetric water content. Since the dielectric constant of water is much higher than that of air or soil minerals, the dielectric constant of the soil is a sensitive measure of water content. The sensor's two-prong design and higher measurement frequency allows the EC-5 to measure VWC from 0 to 100%, and allows accurate measurement of all soil types and a much wider range of salinities.

8.4 eS1301 leaf wetness sensor

The eS1301 uses the leaf wetness sensor from Decagon. Many fungal and bacterial diseases affect plants only when moisture is present on a leaf surface. The eS1301 determines the presence and duration of canopy wetness, allowing users to forecast disease and protect the plant canopy. Since the Leaf Wetness Sensor measures the dielectric constant, droplets do not need to bridge electrical traces for the sensor to detect moisture. The presence of water or ice anywhere on the surface of the sensor will be detected.

Figure 8-5. eS1301 leaf wetness sensor

8.4.1 Installing the Sensor

The leaf wetness sensor is designed to be deployed either in the canopy or on weather station masts. There are two holes in the non-sensing portion of the sensor body for mounting. The holes can be used with either zip ties or with 4-40 bolts.

The sensor leads can be extended up to 250 feet without signal attenuation. When using extension cables in an unprotected environment, the junctions between cables must be waterproofed. This can be effectively accomplished by connecting the junction, applying silicone sealant to the junction, and shrinking appropriately sized heat-shrink tubing over the still-wet silicone sealant.

8.4.2 How does the leaf wetness sensor work?

The leaf wetness sensor measures the dielectric constant of a zone approximately 1 cm from the upper surface of the sensor. The dielectric constant of water (80) and ice (5) are much higher than that of air (1), so the measured dielectric constant is strongly dependent on the presence of moisture or frost on the sensor surfaces. The sensor outputs mV signal proportional to the dielectric of the measurement zone, and therefore proportional to the amount of water or ice on the sensor surface.

8.4.3 What does the sensor reading mean?

The leaf wetness sensor outputs raw binary data, there are no engineering units associated with the sensor (such as deg C). It outputs 445 raw counts when dry. When the sensor is totally wet,

as in a heavy rain, the signal can range up to around 1400 counts. Varying amounts of water on the surface of the sensor cause a sensor output proportional to the amount of water on the sensor's surface. Most leaf wetness applications (disease forecasting, etc.) don't require knowledge of the *amount* of water on the surface - only if there is *any* water on the surface. To make this determination, a sensor output threshold corresponding to the minimum wet state must be identified.

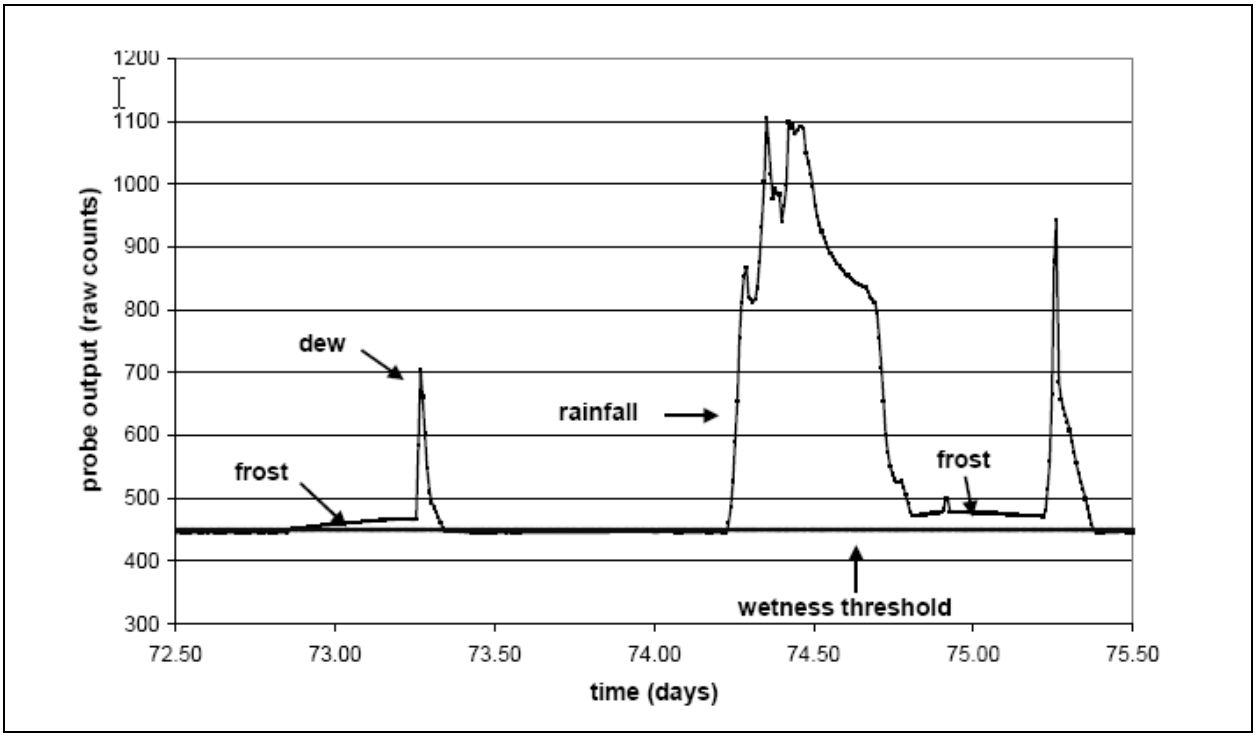


Figure 8-6. Sample raw output from the leaf wetness sensor

8.5 eS1401 solar radiation sensor

The eS1401 uses solar radiation sensor from Davis. It measures global radiation, both the direct and diffuse components of solar irradiance. This allows users to monitor evapotranspiration. From the sensor's output voltage, the console calculates and displays solar irradiance. It also integrates the irradiance values and displays total incident energy over a set period of time.

Figure 8-7. eS1401 solar radiation sensor

Diffuser element and housing are carefully designed for accurate cosine response. Silicon photo diode provides good match to solar spectrum. Two-piece housing minimizes radiation heating, allows convection cooling of the sensor, and prevents the trapping of water or dust.

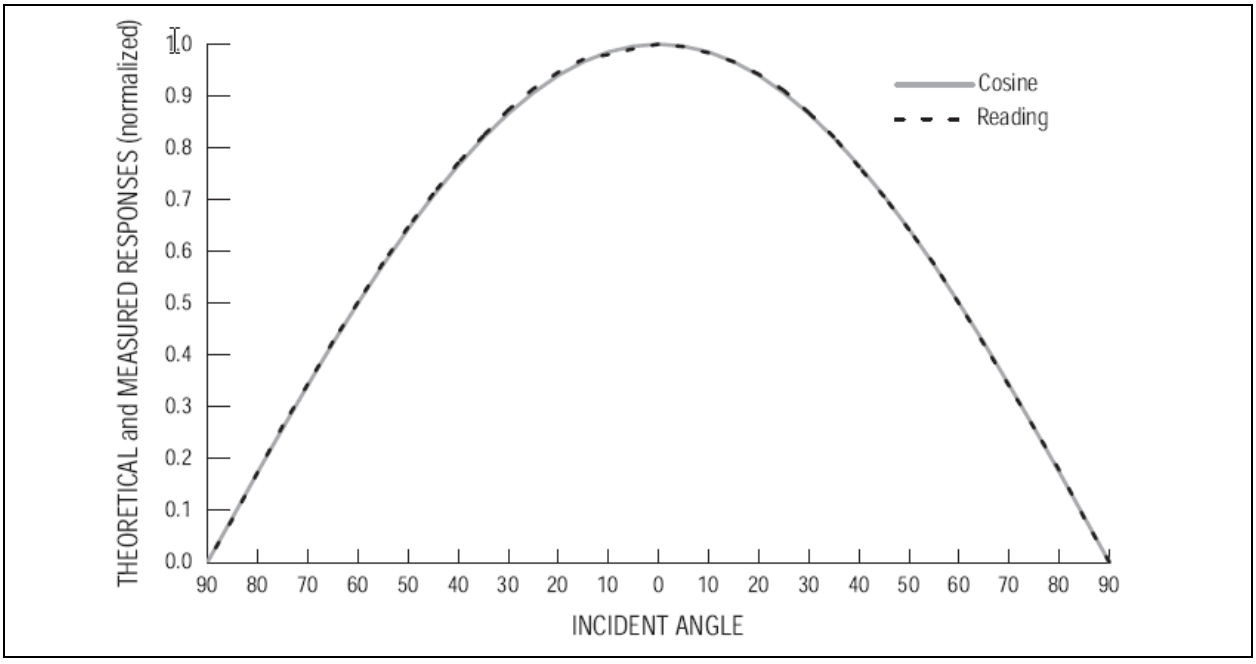


Figure 8-8. Typical cosine response from the solar radiation sensor

8.5.1 Installing the Sensor

Spring-loaded mounting screws, in conjunction with the level indicator, enable rapid and accurate leveling of the sensor. The Solar Radiation sensor is designed to be mounted on the Sensor Mounting Shelf (Davis Instruments Product Number 6672). The Sensor Mounting Shelf is a stand that attaches to your sensor and provides a mounting location for up to two sensors.

For the most accurate readings, clean the diffuser after mounting, and then periodically. Use ethyl alcohol (NOT rubbing alcohol) or water with a little detergent in it.

9 Appendix C. Managing Agricultural Calculations

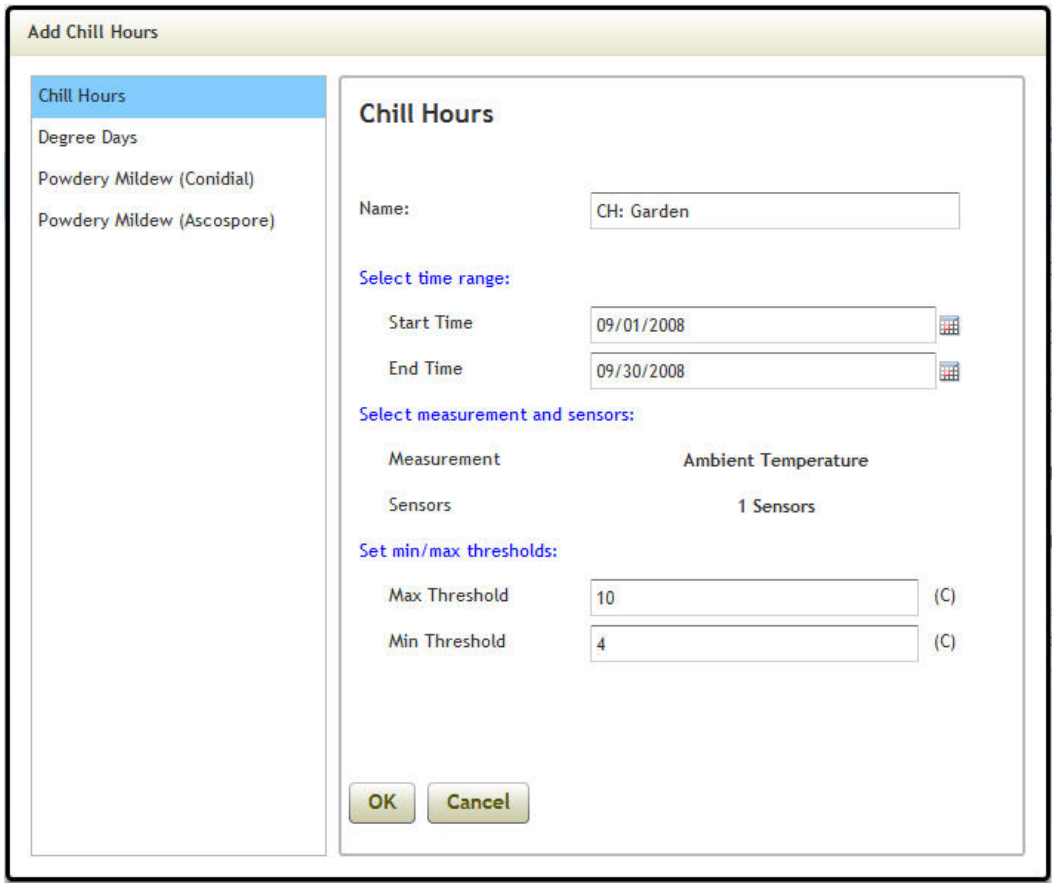
9.1 Chill Hours Calculation

Some crops develop their vegetative and fruiting buds in the summer and, as winter approaches, the already developed buds go dormant in response to both shorter day lengths and cooler temperatures. This dormancy or sleeping stage protects these buds from oncoming cold weather. Once buds have entered dormancy, they will be tolerant to temperatures much below freezing and will not grow in response to mid-winter warm spells. These buds remain dormant until they have accumulated sufficient chill hours of cold weather. When enough chilling accumulates, the buds are ready to grow in response to warm temperatures. As long as there have been enough chill hours, the flower and leaf buds develop normally. If the buds do not receive sufficient chilling temperatures during winter to completely release dormancy, crops can develop one or more physiological symptoms.

Refer to the http://aggie-horticulture.tamu.edu/stonefruit/chillacc.htm for more information on this calculation.

Configuring the Chill Hours Calculation

Chill Hours can be performed on any temperature sensor in the eKo network. Typically users would choose the eKo eS1201 ambient temperature for best results.



9.2 Degree Days (Heat)

Temperature controls the developmental rate of many organisms. Plants and invertebrate animals, including insects and nematodes, require a certain amount of heat to develop from one point in their life cycles to another. This measure of accumulated heat is known as physiological time. Theoretically, physiological time provides a common reference for the development of organisms. The amount of heat required to complete a given organism's development does not vary—the combination of temperature (between thresholds) and time will always be the same. Physiological time is often expressed and approximated in units called degree-days (°D).

Upper and lower developmental thresholds have been determined for some organisms through carefully controlled laboratory and field experiments. For example, the lower developmental threshold is 51°F and the upper developmental threshold is 90°F for the San Jose scale (*Quadraspidiotus perniciosus*). Thresholds vary with different organisms.

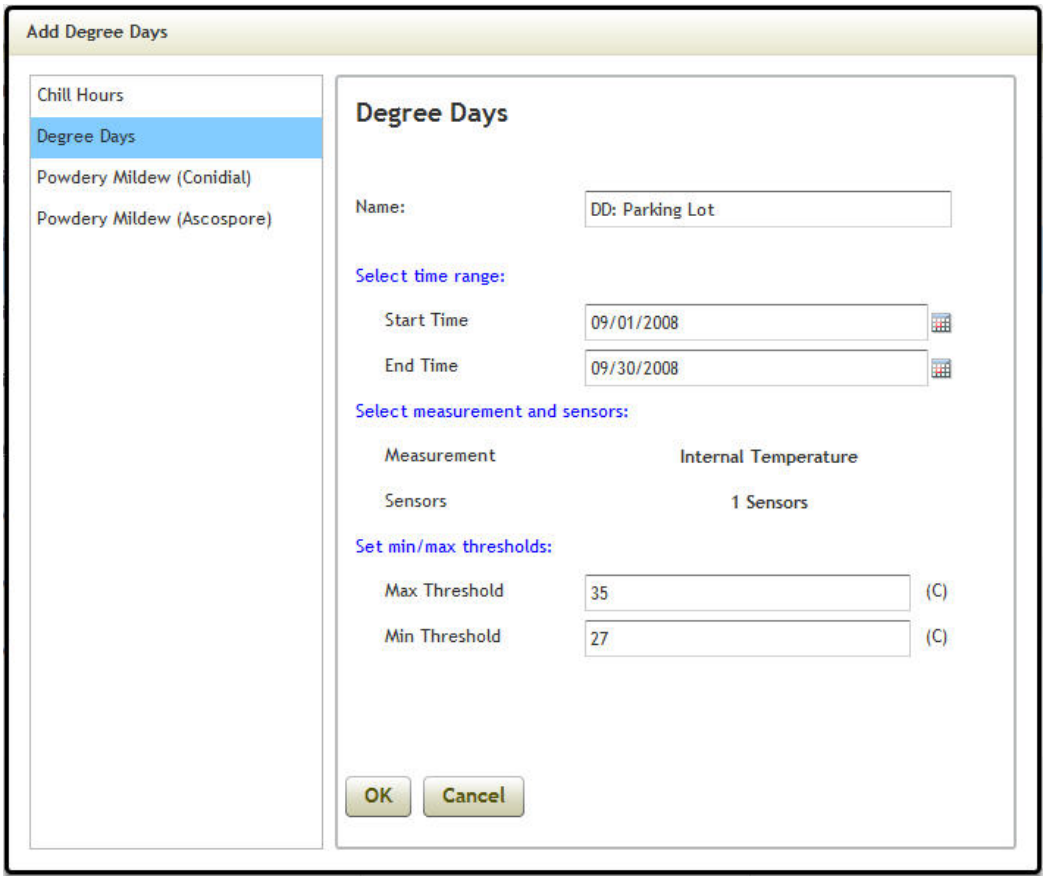
The lower developmental threshold for an organism is the temperature below which development stops. The lower threshold is determined by the organism's physiology. It is independent of the method used to calculate degree-days.

The upper developmental threshold is the temperature above which the rate of growth or development begins to decrease or stop as determined by the cutoff method.

Refer to the UC Davis site for more detailed information and also the upper and lower thresholds used in the calculation: (http://www.ipm.ucdavis.edu/WEATHER/ddconcepts.html)

Configuring the Degree Day Calculation

Configure this calculation similar to chill hours but with the appropriate upper and lower limits.



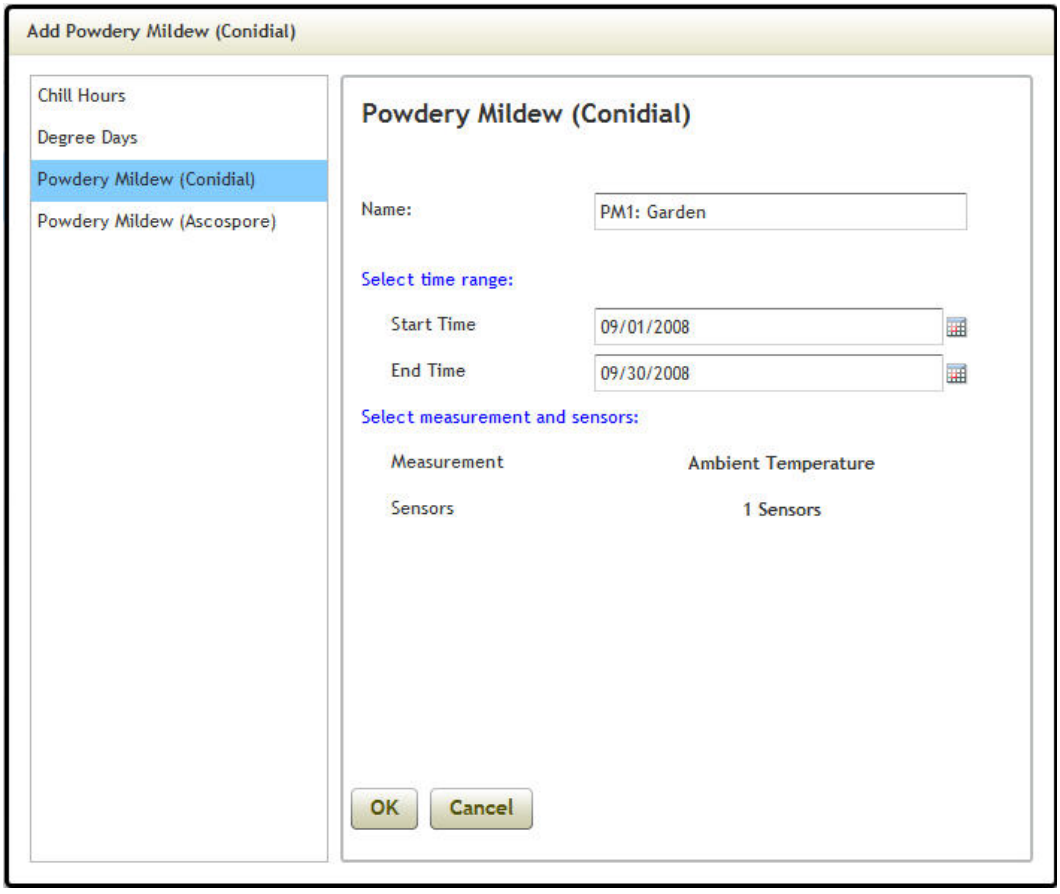
9.3 Powdery Mildew (Conidial)

In order for the powdery mildew epidemic to begin, the pathogen requires three consecutive days when there is a minimum of 6 hours of temperatures between 21 and 30°C. If three consecutive days at these temperatures are not met, the index reverts to zero. For each day that this requirement is met, 20 index points are assigned. After 3 days, an index of 60 would be achieved thus triggering the index. Once the 3 consecutive day requirement is met, it no longer is a function of the model. The model will fluctuate between 0 and 100. Losing 10 points on days when the 6 hour requirement for 21-30°C was not met or if at any time during the day, the temperature rose to 35°C for at least 15 min. An index of 60-100 indicates the pathogen is reproducing every 5 days while an index of 0-30 indicates a reproductive rate of 15 days or less. An index of 40-50 is considered normal and would imply a reproductive rate of 8-11 days, i.e., somewhere between a 5 and 15 day reproductive rate.

Refer to the website http://www.apsnet.org/online/feature/pmildew/ for further details.

Configuring the Powdery Mildew (Conidial) Calculation

All configuration parameters are the same as the Chill Hours except the temperature thresholds are predetermined by the model.



9.4 Powdery Mildew (Ascospore)

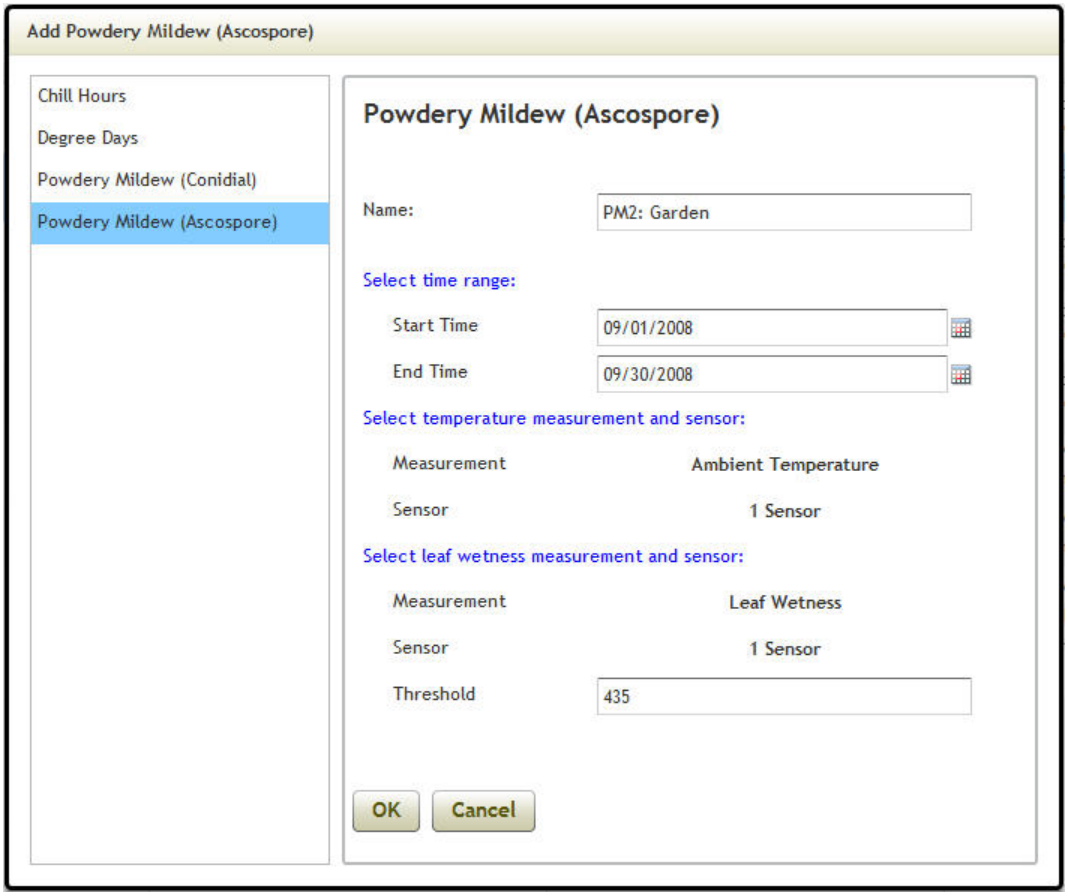
The ascospore portion of the model forecasts ascospore release based on leaf wetness and temperature. This requires a Leaf Wetness sensor such as the Crossbow eS1301.

The Ascospore calculation is based on the average temperature during an extended leaf wetness event. The model utilizies the 'Conidial Mills Table' at 2/3 value for hours of leaf wetness required at various temperatures. In general, at least 12-15 hours of continuous leaf wetness are required when average temperatures are between 10-15 deg C.

Refer to the website http://www.apsnet.org/online/feature/pmildew/ for further details.

Configuring the Powdery Mildew (Ascospore) Calculation

Configuration parameters except for the leaf threshold are similar to previous calculations. The leaf wetness sensor (Decagon) output binary data, there are no engineering units associated with the sensor (such as deg C). The graph below shows a typical output. Threshold values around 450 are typical.



10 Appendix D. ēKo Accessories

Antenna and cable accessories that have been tested with ēKo are listed below.

Product	Manufacturer	Model	Manufacturer's web site
Outdoor Antennas and RF cables			
Outdoor omni antenna	Hawking	HAO9SIP	http://www.hawkingtech.com
Outdoor 20' RF extender cable	L-com	CA4NMRSF020	http://www.l-com.com/
Indoor Antennas			
Indoor omni antenna	Airlink	ASB-10MA	http://www.airlink101.com
Indoor directional antenna	Airlink	ASB-10DA	http://www.airlink101.com

11 Appendix E. Warranty and Support Information

11.1 Customer Service

As a Crossbow Technology customer you have access to product support services, which include:

- Single-point return service
- Web-based support service
- Same day troubleshooting assistance
- Worldwide Crossbow representation
- Onsite and factory training available
- Preventative maintenance and repair programs
- Installation assistance available

11.2 Contact Directory

United States: Phone: 1-408-965-3300 (8 AM to 5 PM PST)
Fax: 1-408-324-4840 (24 hours)
Email: eko.support@xbow.com

Non-U.S.: refer to website www.xbow.com/eKo

11.3 Return Procedure

11.3.1 Authorization

Before returning any equipment, please contact Crossbow to obtain a Returned Material Authorization number (RMA).

Be ready to provide the following information when requesting a RMA:

- Name
- Address
- Telephone, Fax, Email
- Equipment Model Number
- Equipment Serial Number
- Installation Date
- Failure Date
- Fault Description

11.3.2 Identification and Protection

If the equipment is to be shipped to Crossbow for service or repair, please attach a tag TO THE EQUIPMENT, as well as the shipping container(s), identifying the owner. Also indicate the service or repair required, the problems encountered and other information considered valuable to the service facility such as the list of information provided to request the RMA number.

Place the equipment in the original shipping container(s), making sure there is adequate packing around all sides of the equipment. If the original shipping containers were discarded, use heavy boxes with adequate padding and protection.

11.3.3 Sealing the Container

Seal the shipping container(s) with heavy tape or metal bands strong enough to handle the weight of the equipment and the container.

11.3.4 Marking

Please write the words, "***FRAGILE, DELICATE INSTRUMENT***" in several places on the outside of the shipping container(s). In all correspondence, please refer to the equipment by the model number, the serial number, and the RMA number.

11.3.5 Return Shipping Address

Use the following address for all returned products:

Crossbow Technology, Inc.
4145 N. First Street
San Jose, CA 95134
Attn: RMA Number (XXXXXX)

11.4 Warranty

The Crossbow product warranty is one year from date of shipment.

The following statement applies to eB2110 ēKo base radio and eN2100 ēKo node:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

CAUTION: Changes or modifications not expressly approved by Crossbow Technology, Inc could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area may cause harmful interference in which the users will be required to correct the interference at their own expense.

Safety Information

The radiated output power of this internal wireless radio is far below the FCC radio frequency exposure limits. Nevertheless, the wireless radio shall be used in such a manner that the radio is 20 cm or further from the human body.

The internal wireless radio operates within guidelines found in radio frequency safety standards and recommendations, which reflect the consensus of the scientific community.

Crossbow Technology, Inc therefore believes the internal wireless radio is safe for use by consumers. The level of energy emitted is far less than the electromagnetic energy emitted by wireless devices such as mobile phones. However, the use of wireless radios may be restricted in some situations or environments, such as aboard airplanes. If you are unsure of restrictions, you are encouraged to ask for authorization before turning on the wireless radio.

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